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ABSTRACT

This learner's guide on nutrients is derived from a water monitoring curriculum developed at Ulster County Community College. There are 30 modules in this guide; each introduced with a statement of purpose and then broken down into an objective, learning conditions, and performance level. The modules cover: (1) safety; (2) chemical compounds; (3) equipment utilization; (4) biochemical reactions; and (5) chemical determinations. Among the chemical tests included are those for oxygen, chlorine, nitrogen, phosphorus, carbon, pH, and hardness. (CS)

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NUTRIENTS

Learner's Guide For A Critical Path In Water Quality Monitoring

February 1979

AWARDED TO

Water Quality Monitoring Project
Ulster County Community College
Stone Ridge, New York 12484

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Dedicated to Anna May Gibbons, a very special assistant whose devotion to this work, personal dedication, and long hours can never be fully repaid.

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Introduction

This learner's guide on nutrients is derived from *A Two-Year Water Monitoring Curriculum*, published in 1975 and developed at Ulster County Community College. The entire curriculum was written using the instructional objectives format. One of the many advantages of such a curriculum is the capability it provides for taking its independent learning units (the objectives) out of context and rearranging them in different sequences or courses to meet new or more immediate training needs. The authors of the curriculum and of this learner's guide have designated these sequences as "critical paths."

The critical path in this particular learner's guide leads the trainee to a mastery of the skills necessary for determining nutrients (namely, organic nitrogen, Kjeldahl nitrogen, ammonia, nitrate, nitrite, orthophosphate, and total phosphate). When it becomes necessary to train a technician to conduct these tests, or when the technician or student desires to learn how to conduct these tests on his own, the skills can be developed by mastering the sequenced objectives contained herein.

The objectives found in the instructional modules (courses) in this book, except those dealing with safety procedures, are taken from *A Two-Year Water Quality Monitoring Curriculum.** Because of the importance of correct safety procedures in the laboratory at all times, the authors believe that all critical paths for laboratory procedures should begin with modules on safety.

The mathematics modules, while following the same format as the modules on chemistry and environmental science, contain, in addition, sample solved problems with answers.

The objectives in this critical path for nutrients are not strictly theoretical. They have been tested extensively with great success during the past three years in the Water Management Program at Ulster County Community College. The user of this learner's guide can rest assured that the objectives have instructional validity.

The intent of this guide and others in the series that were developed from *A Two-Year Water Monitoring Curriculum* is to take the trainee through the step-by-step sequences required to master very specific sets of skills for very specific job functions. When the instructional objectives are complemented with appropriate audio-visual aids, they provide an almost completely independent, self-paced learning system that offers the instructor the flexibility to become a manager of learning and frees the student from the rigid constraints of more classical, or traditional, educational procedures.

*The environmental science modules are taken directly from the *Learner's Guide: Water Quality Monitoring*, published in June 1978. These modules were also developed from the two-year curriculum.

How To Use This Book

There are thirty courses (or modules) in this guide. Each course is introduced with a statement of purpose, and then broken down into a number of units of instruction, each containing an objective (OBJ), learning conditions (COND), and a performance level (PL).

The statement of purpose is a synopsis of the course material and explains what the student will be studying. It deals with the relevance of the subject material and explains why the student is to master the course skills and knowledge covered in the course. The student should understand why he should master the learning objectives and how the course fits into the total sequence of his learning.

The OBJ tells the student precisely what he must be able to do after mastering each distinct unit of instruction.

The COND tells the student (and the instructor) the circumstances under which the student will perform or the objects, information or assistance the student will have access to while performing. The student should perform under conditions as close to real situations as is practical in the instructional situation.

The PL tells the student the acceptable level of performance that will be required of him to demonstrate mastery of the objective.

Each course (module) is cross referenced to *A Two-Year Water Quality Monitoring Curriculum.** The title of each complete learning module is indicated at the top of the page, with the location in the curriculum coded by curriculum course name and number. The descriptive prefix and the first number refer to the curriculum course in which the module's objectives are found. The second number, following the colon, refers to the number of the pertinent objective in the curriculum, and the third number (in parentheses), is the page in the curriculum on which that objective is found. An example would be:

Math 101:12(44)

This would be read as Mathematics 101, objective 12, page 44 (inequalities) in the two-year curriculum.

*Ulster County Community College, 1975, with the exception of the first three modules on safety.

Courses

Personal Safety

PURPOSE

This guide will help you learn to use safety rules and equipment to protect yourself, others, and the laboratory. Many wait until an emergency happens to learn where equipment is and how to use it. Practicing safety rules eliminates most accidents and minimizes others.

PREREQUISITES

None.

RESOURCES

IRIS: 2911 (Module 1)

OBJECTIVES

OBJ 1: State and use safety rules concerning eyeglasses, lab coats, gloves, and working alone.

COND: From recall.

PL: State all rules in your own words.

OBJ 2: Locate the safety equipment in your laboratory.

COND: Given a stocked laboratory or a sketch or photograph of a lab.

PL: All of the following should be located within 5 minutes:

a. Safety shower
b. First-aid kit and safety sheet
c. Eyewash fountain
d. Fire blanket

OBJ 3: Operate a safety shower and describe how and when to use it.

COND: Given a stocked chemical laboratory or a sketch or photograph of a lab.

PL: Simulate the use of the shower and state when to use it.

OBJ 4: Operate an eyewash fountain.

COND: Given an eyewash fountain, or a sketch or photograph of a fountain, and a towel.

PL: Use of the fountain should be demonstrated for 1 minute, with identification of hazards, such as striking an eye against the fountain.

OBJ 5: Identify the contents of a first-aid kit and describe the use of each item.

COND: Given the kit and an instruction sheet.

PL: Include treatment of:

a. Minor and major heat burns
b. Minor and major chemical burns
c. Minor and major cuts

OBJ 6: Describe or demonstrate the use or a fire blanket.

COND: Given a blanket and an instruction sheet.

PL: Quickly, but without rushing, move to the blanket and follow each step in the instructions within 2 minutes.

OBJ 7: Describe or demonstrate how to smell chemicals and state that chemicals must *never* be tasted.

COND: State from recall and demonstrate, given a bottle of ammonia.

PL: 100%.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES							
	1	2	3	4	5	6	7	8
Safety glasses	x	x	x	x	x	x	x	
Safety shower		x	x				x	
Eyewash fountain		x		x			x	
First-aid kit		x			x		x	
Fire blanket		x				x		
Ammonia solution							x	

Fire Safety

PURPOSE

This guide will help you learn to handle laboratory fires which may occur. Fires are one of the most common and dangerous accidents which can happen and prompt action can prevent or minimize damage to people and property.

PREREQUISITES

Before beginning this module you should have successfully completed the previous module on personal safety.

RESOURCES

IRIS: 2911 (Module 2)

OBJECTIVES

OBJ 1: List safety rules for working in the laboratory.

COND: From recall.

PL: State in your own words, including rules about not working alone, using safety glasses, fire prevention, and how to put out and report fires.

OBJ 2: Locate all fire safety features in your laboratory.

COND: Given a stocked laboratory or a sketch or photograph of it.

PL: Locate fire extinguishers, fire blanket, fire alarm, and an escape route.

OBJ 3: Describe how to use CO_2 and dry chemical extinguishers.

COND: Given a stocked laboratory, a type of fire, and an instruction sheet.

PL: Identify:

a. The correct extinguisher for a given type of fire.
b. The safety pin, and how to remove it.
c. The trigger, and how to use it.
d. The portion of the fire to be directly attacked.

OBJ 4: Describe how to set off a fire alarm.

COND: Given a sketch, photograph, or model of a fire alarm.

PL: Include:

a. When to set off an alarm.
b. Never set off a false alarm, and state why.
c. How to leave the building after setting off the alarm.
d. Report to fire chief as soon as he arrives.
e. How to use the fire blanket.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
CO_2 fire extinguisher		x	x					
Dry chemical fire extinguisher		x	x					
Fire blanket		x						
Fire alarm or sketch				x				

Prevention and Treatment of Laboratory Accidents

PURPOSE

This guide will help you learn to prevent laboratory accidents and the proper steps to follow if an accident occurs. Personal injury can be minimized and much time and money saved if proper laboratory skills are used to prevent accidents.

PREREQUISITES

Before beginning this module you should have successfully completed the previous modules on personal safety and fire safety.

RESOURCES

IRIS: 2911 (Module 3)

OBJECTIVES

OBJ 1: State basic laboratory safety rules.

COND: From recall.

PL: Include that you must:

a. Wear safety glasses at all times.
b. Wear lab coats or aprons when handling corrosive chemicals.
c. Wear protective shoes.
d. Wear rubber gloves when handling chemicals harmful to the skin.
e. Maintain a clean laboratory.
f. Place hot objects on a protective mat, such as asbestos.
g. Keep chemicals properly labeled and in their appropriate place.

OBJ 2: Describe the purpose of a fume hood and demonstrate its use.

COND: Given a fume hood and an instruction sheet.

PL: The hood should always be used with any volatile chemicals.

OBJ 3: Describe how to dispose of solid and liquid wastes.

COND: From recall.

PL: Description should differentiate between potentially poisonous chemicals and those presenting no health hazard which can be disposed of in water drain or in normal solid waste disposal.

OBJ 4: Describe and demonstrate how to insert glass tubing into rubber tubing or stoppers.

COND: Given a stocked laboratory.

PL: Glass must be fire-polished, lubricated and carefully inserted. Hands must be protected with a towel, and the lubricant must not be chemically reactive with the reagents to be used.

OBJ 5: Describe and demonstrate safety procedures to be followed for basic laboratory skills.

COND: Given a stocked chemical laboratory and instruction sheets.

PL: Include:

a. Always add acid to water, never water to acid.

b. Combine chemicals slowly to prevent overheating if reaction occurs.
c. Remove chemicals from storage containers carefully to prevent accidents and contamination.
d. Proper method of heating glassware.

OBJ 6: Review all safety rules, then describe the proper action to take in case of a specific laboratory accident.

COND: Given the circumstances of an accident involving fire or chemicals in the laboratory or on the body.

PL: Include potential dangers, need for speed, selection of proper protective devices, and describe the steps to be followed to minimize damage.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES							
	1	2	3	4	5	6	7	8
Fume hood		x						
Beaker		x						
Glass tubing				x				
Rubber tubing or stopper				x				
Towel				x				
Bunsen burner					x			
Wire gauge and ring stand					x			
Ammonia solution (NH_4OH)		x						
6M Sulfuric acid (H_2SO_4)					x			

Inequalities
MATH 101:12 (44)

PURPOSE

This guide will assist you in learning how to use the mathematical concepts of "greater than," "less than," "greater than or equal to," and "less than or equal to." These mathematical concepts and the symbols used to represent these concepts are often found in tables of effluent-influent standards and in NPDES permits.

PREREQUISITES

Before beginning this module you should have successfully completed appropriate high school mathematics courses.

RESOURCES

Algebra texts

OBJECTIVES

OBJ 1: Draw a coordinate line and represent seven points on that line.

COND: Given 2 solved "sample problems," a ruler, 3 negative numbers, 3 positive numbers, and the number zero.

PL: Coordinate line must be properly labeled and the 7 numbers must be represented with 100% accuracy.

OBJ 2: Demonstrate the meaning of the symbols $<$, $\leq$, $>$, and $\geq$ on a coordinate line.

COND: Given 5 solved "sample problems," a ruler, and 10 inequality relationships.

PL: Coordinate line must be properly labeled and 9 out of the 10 inequality relationships must be represented with 100% accuracy.

EQUIPMENT AND SUPPLIES

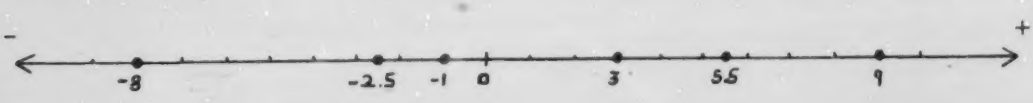
None.

SOLVED SAMPLE PROBLEMS

OBJ 1:

a. Represent the numbers -8, -2.5, -1, 0, 3, 5.5, and 9 on a coordinate line.

Solution:



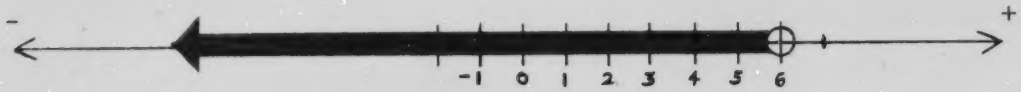
b. Represent the numbers -500, -350, -100, 0, 150, 350, and 450 on a coordinate line.

Solution:

OBJ 2:

a. Represent $x < 6$ on a coordinate line.

Solution:

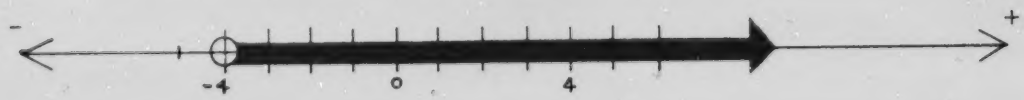


b. Represent $x \leq 6$ on a coordinate line.

Solution:

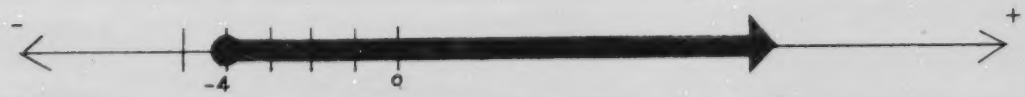
c. Represent $x > -4$ on a coordinate line.

Solution:



d. Represent $x \geq -4$ on a coordinate line.

Solution.



e. Represent $x \leq -2$ on a coordinate line.

Solution:

Graphing
MATH 101:32 (47)

PURPOSE

This guide will assist you in drawing graphs on rectangular, semi-log, and log-log paper. Graphing is one technique which is often used to make sense out of a mass of unorganized data. Not only is the pictorial form of the data more easily analyzed, but any deviations, trends, duplications, and errors are more easily identified.

PREREQUISITES

Before beginning this module you should have successfully completed Math 101:12 (44) and appropriate high school mathematics courses.

RESOURCES

"Mini-Courses in Math: Module 10" by
Educational Tutorial System
1220 Fifth Street
Santa Monica, CA 90401

OBJECTIVES

OBJ 1: Using the "three-quarter high rule," graph on rectangular coordinate paper a group of ordered pairs.

COND: Given a description of the "three-quarter rule" method, two solved sample problems, three sheets of rectangular coordinate paper, a ruler, and a list of six ordered pairs which must be graphed.

PL: The six ordered pairs must be represented with 100% accuracy, the graph must demonstrate the "three-quarter rule," and the graph must be neat and properly labeled.

OBJ 2: Graph on semi-log paper a group of ordered pairs.

COND: Given one solved "sample problem," three sheets of semi-log paper, a ruler, and a list of six ordered pairs which must be graphed.

PL: The six ordered pairs must be represented with 100% accuracy and the graph must be neat and properly labeled.

OBJ 3: Graph on log-log paper a group of ordered pairs.

COND: Given two solved "sample problems," three sheets of log-log paper, a ruler, and a list of six ordered pairs which must be graphed.

PL: The six ordered pairs must be represented with 100% accuracy and the graph must be neat and properly labeled.

SOLVED SAMPLE PROBLEMS

OBJ 1: The "three-quarter high rule" is expressed as follows: In plotting data, the vertical axis should be laid out so that the height of the maximum data point is approximately equal to three-quarters the length of the horizontal axis.

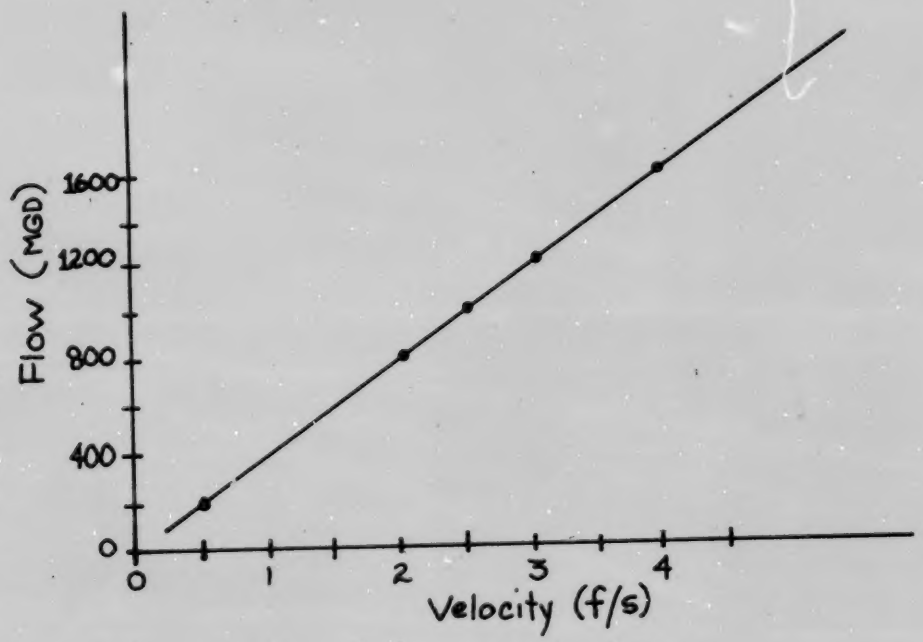
Solved Problems

a. Plot the following data on rectangular coordinate paper:

velocity (f/s)	flow (MGD)
.5	200
1.0	400
2.0	800
2.5	1000
3.0	1200
4.0	1600

Using Citadel 11 x 8½ sheets with 10 squares to the inch (or equivalent paper) the solution is as follows:

1. Velocity is chosen as the horizontal or x - axis and 20 squares are used to represent 1 f/s.
2. Since the horizontal axis uses 80 squares (20 x 4 f/s), the vertical or flow axis should use approximately 60 suqres (3/4 x 80).
3. The plot below indicates correct positioning of the data.

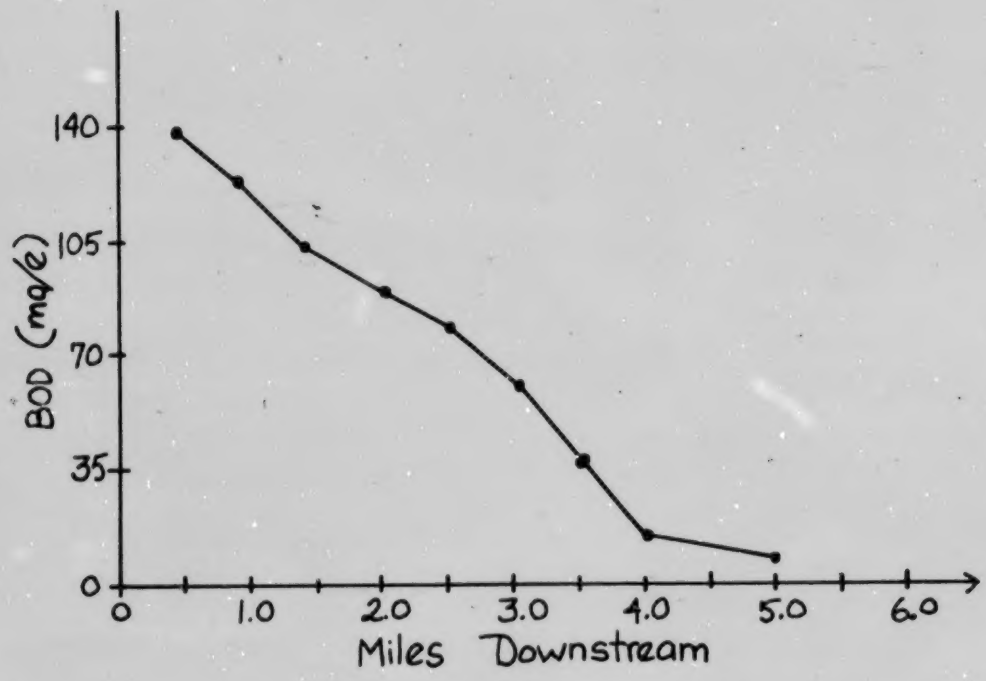


b. Plot the following data on rectangular coordinate paper:

Miles Downstream	BOD
.5	138
1.0	120
1.5	104
2.0	90
2.5	74
3.0	54
3.5	33
4.0	13
5.0	10

Using 10-squares-to-the-inch paper as in the previous problem, the solution is as follows:

1. Miles are chosen as the horizontal axis and 20 squares are used to represent 1 mile.
2. Since the horizontal axis used 100 squares (20 x 5 mile), the vertical (BOD) axis should use approximately 75 squares (3/4 x 100).
3. The plot below indicates correct positioning of the data.



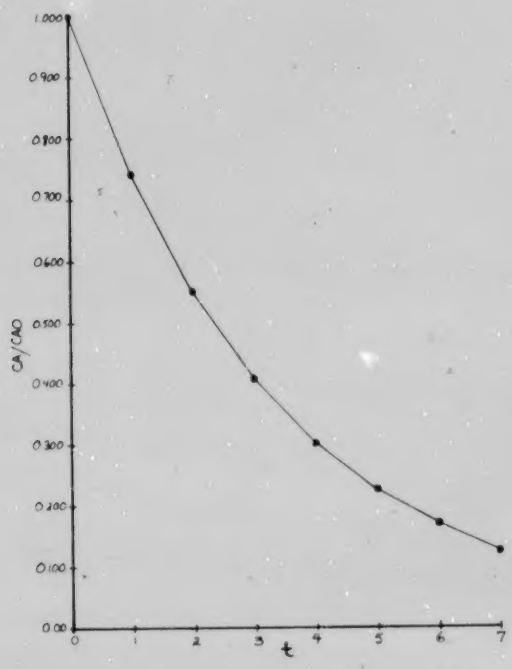
OBJ 2: Ordinarily, rectangular coordinates are used to illustrate the relationship between two variables. However, in some situations, a plot of log y versus x is more advantageous than that of y versus x.

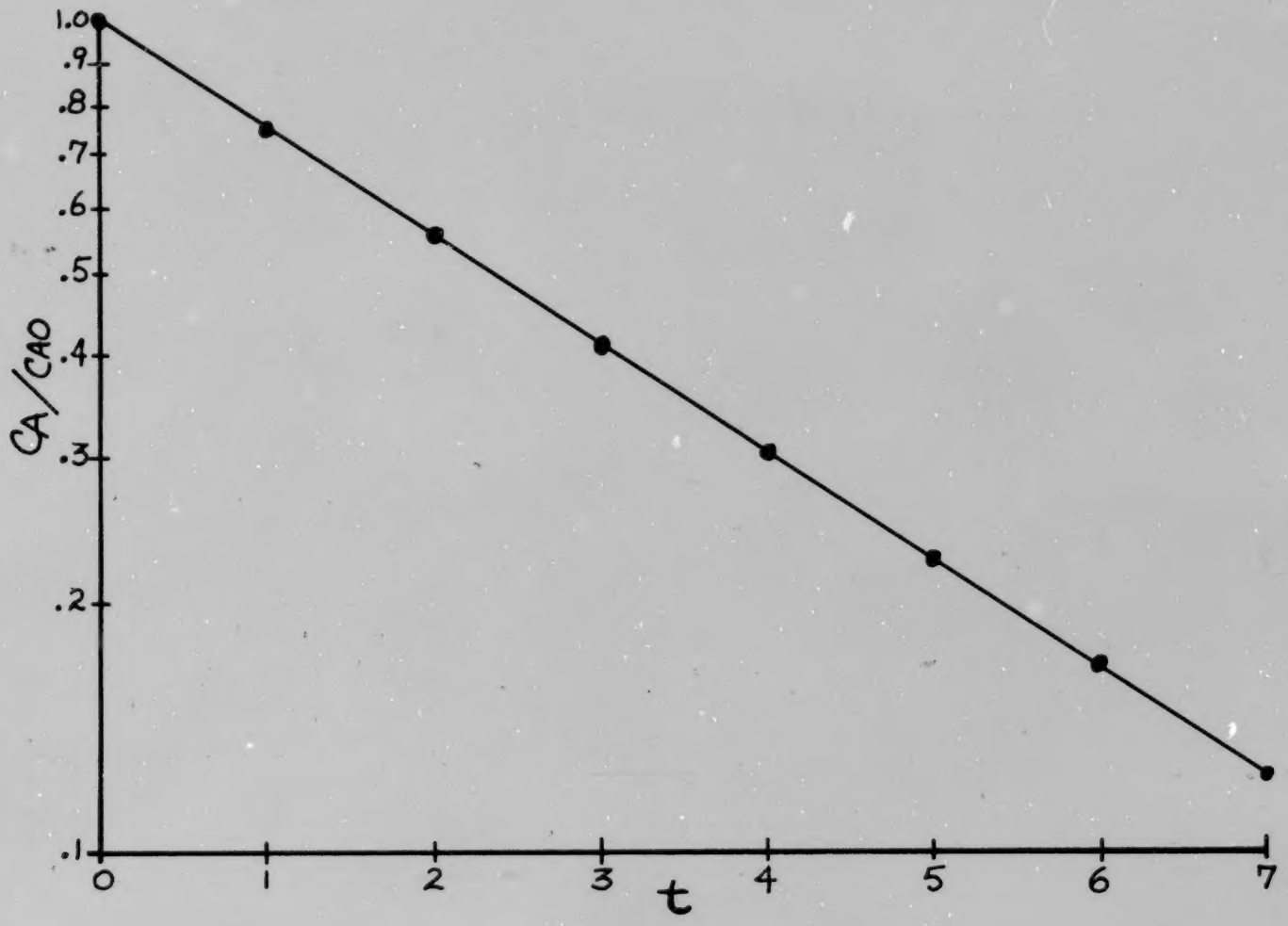
Solved Problem

a. The data below are derived from a unimolecular-type first-order reaction which we will assume depicts rapid utilization of a food supply by bacteria. C_{AO} represents the concentration of the food at the start of the test. Plot the following data on: (1) rectangular coordinate paper and (2) semi-log paper.

C_A/C_{AO}	t
1.000	0
.741	1
.55	2
.407	3
.301	4
.223	5
.167	6
.122	7

Note: These data were generated using the equation $\ln \frac{C_A}{C_{AO}} = -kt$




1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
CA/CAO
0
1
2
3
4
5
6
7
t

OBJ 3: Ordinarily, rectangular coordinates are used to illustrate the relationship between two variables. In many situations a plot of log y versus log x is more advantageous than that of y versus x. Two of the advantages of such a plot are:

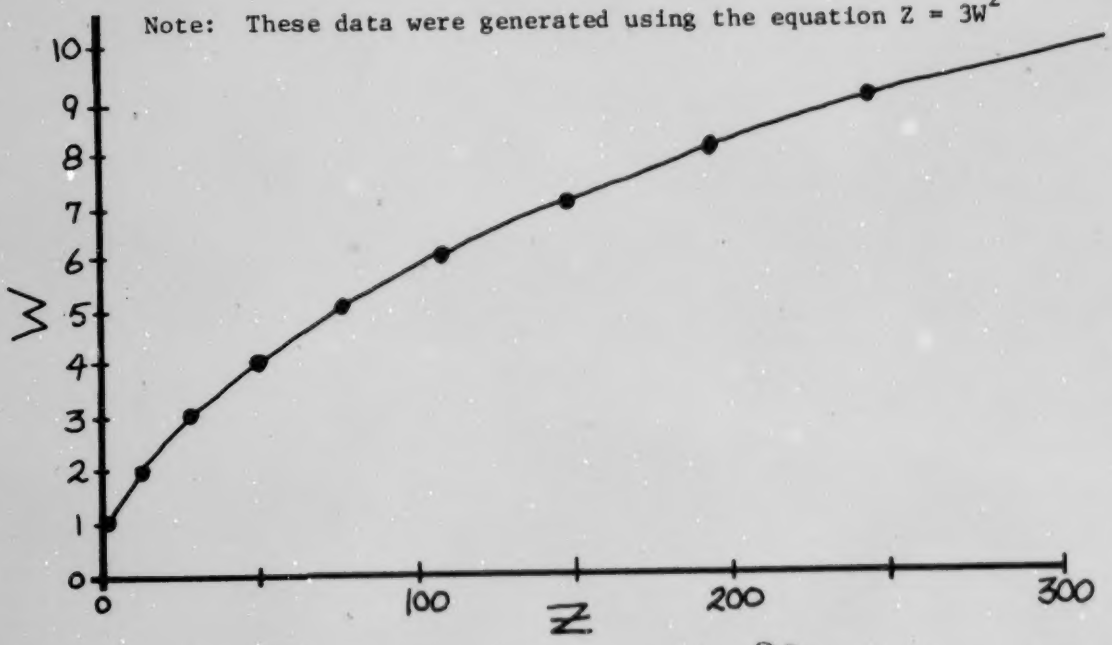
1. When the data (variables) cover a wide range of magnitude, the log-log plot may be used for the entire range.
2. The equation of the form $y = ax^n$, where a and n are constants, gives a straight line on log-log coordinates.

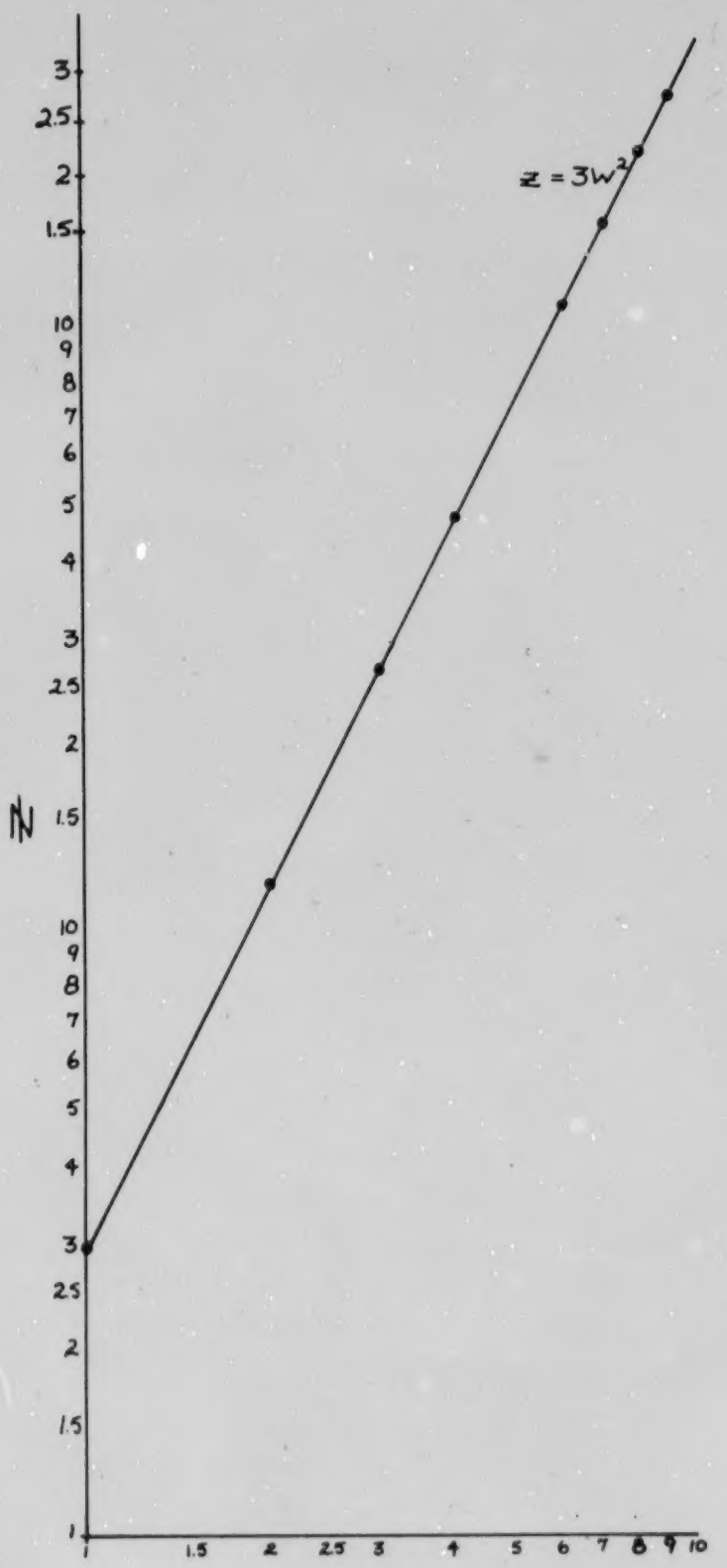
Solved Problems

a. Plot the following data on: (1) rectangular coordinate paper and (2) log-log paper.

W	Z
0	0
1	3
2	12
3	27
4	48
5	75
6	108
7	147
8	192
9	243

Note: These data were generated using the equation $Z = 3W^2$

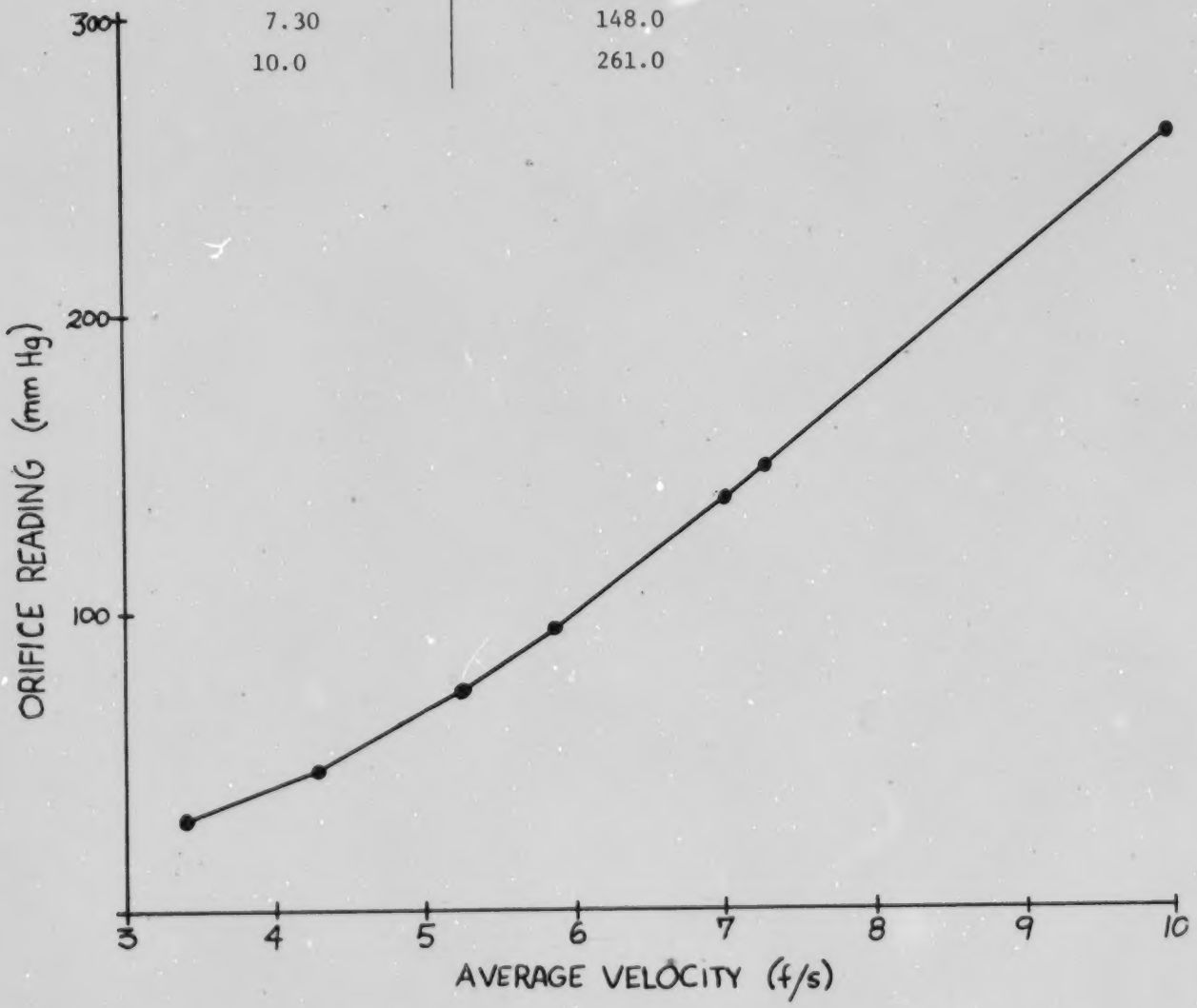


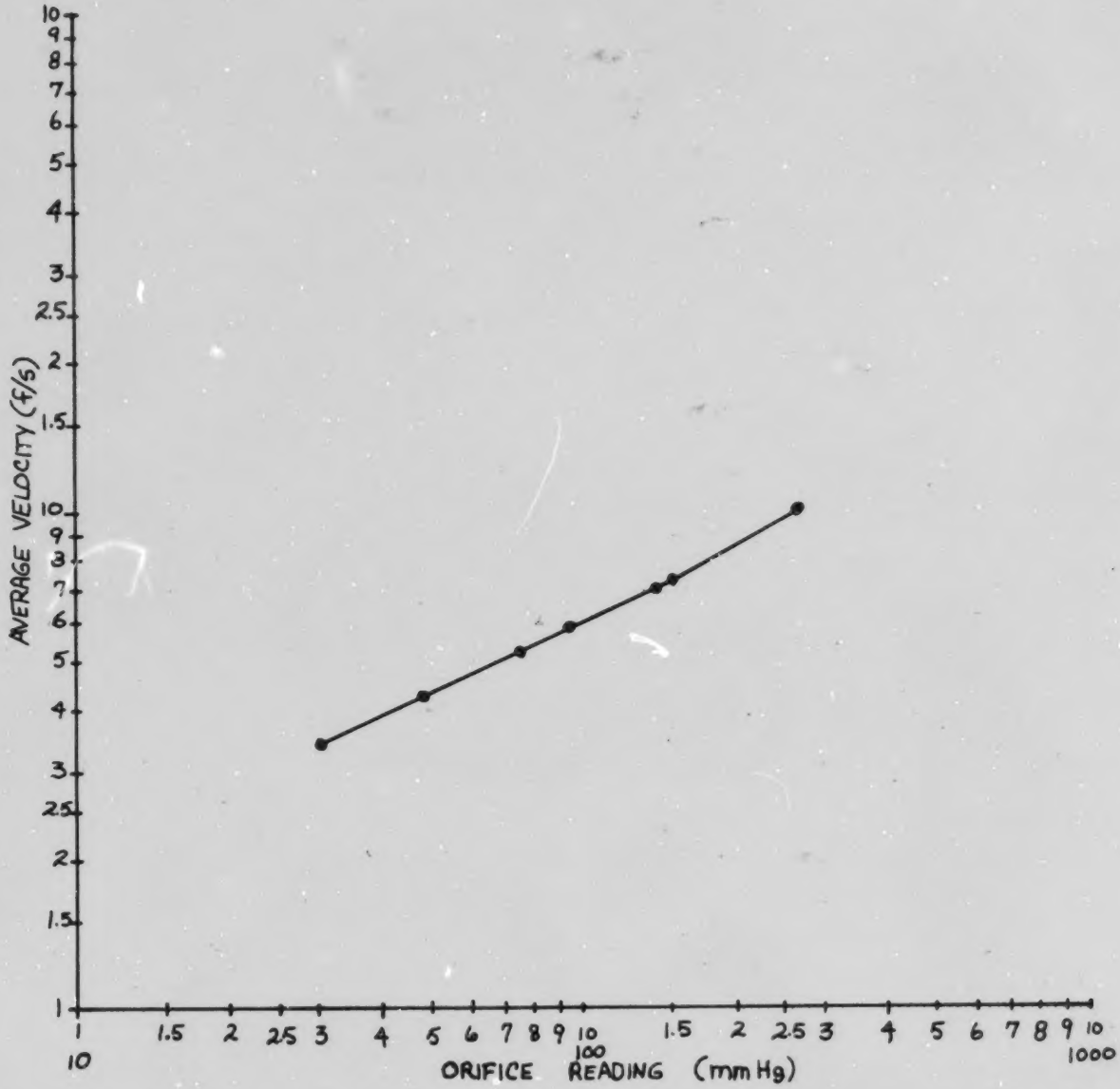

Z = 3W²
N
3
2.5
2
1.5
10
9
8
7
6
5
4
3
2.5
2
1.5
10
9
8
7
6
5
4
3
2.5
2
1.5
1
1
1.5
2
2.5
3
4
5
6
7
8
9
10

W2

b. Plot the following pipeline flow data on: (1) rectangular coordinate paper and (2) log-log paper.

Average Velocity (f/s)	Orifice Reading (mm HG)
3.42	30.3
4.25	48.0
5.25	75.5
5.88	93.5
7.02	137.5
7.30	148.0
10.0	261.0




AVERAGE VELOCITY (f/s)
10
9
8
7
6
5
4
3
2.5
2
1.5
1
10
9
8
7
6
5
4
3
2.5
2
1.5
1
1.5
2
2.5
3
4
5
6
7
8
9
10
100
1.5
2
2.5
3
4
5
6
7
8
9
10
1000
ORIFICE READING (mm Hg)

Names and Formulas of Simple Chemical Compounds

CHEM 101:33 (34)

PURPOSE

This guide will assist you in learning to name or identify chemicals needed to perform many NPDES tests. The correct names and identifications are necessary to get reliable results without causing dangerous laboratory conditions.

PREREQUISITES

None.

RESOURCES

IRIS: 4, 1321 (Chapter 9), 2911 (Modules 5, 6)

OBJECTIVES

OBJ 1: Define the following terms:
- a. Concentrated
- b. Diluted
- c. Saturated
- d. Unsaturated
- e. Anhydrous
- f. Hydrated

COND: From recall.

PL: All terms should be correctly stated in the learner's own words.

OBJ 2: Identify the names and formulas of common chemicals used in wastewater analysis.

COND: Given a list of chemical names and their formulas (practice matching these using the listed resources).

PL: All of the chemicals' names (or formulas) should be correctly matched.

OBJ 3: Choose the correct chemicals for a specific chemical procedure.

COND: Given a list of chemical names and formulas and a written chemical procedure.

PL: All of the chemicals' names in the procedure should be properly matched against the list of formulas.

OBJ 4: Locate the name, formula, and safety precautions from a reagent chemical label.

COND: Given a list of chemical names and formulas, a chemical procedure, and either a stocked reagent shelf or stockroom or a label from a bottle.

PL: All of the chemicals should be identified and the safety precautions stated from the label.

EQUIPMENT AND SUPPLIES

None.

Concentration Calculations

CHEM 101:45a, j, 1 (36)

PURPOSE

This guide will assist you in learning to do calculations important in the use of laboratory supplies and equipment. The calculations are necessary to perform chemical tests such as those used in wastewater analysis.

PREREQUISITES

Before beginning this module you should have successfully completed Chem 101:33 (34) and Math 101:28.

RESOURCES

IRIS: 1321 (Chapters 1, 23), 2911 (Module 27)

OBJECTIVES

OBJ 1: Perform calculations using exponential numbers.

COND: Given resources.

PL: Solve 4 of 5 simple problems within 10 minutes.

OBJ 2: Define these terms:

a. Normality (N)
b. Equivalent weight
c. Number of equivalents
d. Milligram per liter
e. Part per million
f. Concentration
g. Solution

COND: From recall.

PL: Six of the 7 should be defined correctly in the learner's own words.

OBJ 3: Calculate the concentration of a solution in milligrams per milliliter or parts per million.

COND: Given the listed resources or other references and suitable data.

PL: Solve 4 of 5 simple problems in 15 minutes.

OBJ 4: Calculate the equivalent weight of a substance.

COND: Given the periodic chart, the name and formula of the compound, and the reaction that compound undergoes.

PL: Solve 3 of 4 problems within 10 minutes.

OBJ 5: Calculate the normality (N) of a solution.

COND: Given the periodic chart, the weight of solute and the volume of the solution.

PL: Solve 3 of 4 problems within 20 minutes.

EQUIPMENT AND SUPPLIES

None.

Double Pan Analytical Balance

CHEM 101:46f (36)

PURPOSE

This guide will assist you in learning to use the double pan analytical balance. The double pan analytical balance is used for very accurate weighings (± 0.1 mg); it is cheaper than electric balances, but is very slow in operation.

PREREQUISITES

None.

RESOURCES

IRIS: 2911 (Module 19)

OBJECTIVES

OBJ 1: Identify the major features of a double pan analytical balance.

COND: Given the balance or pictures or sketches of this balance.

PL: Include:

a. Balance pans
b. Pan arrests
c. Pan arrest knob
d. Beam
e. Beam support
f. Beam support control knob
g. Knife edges
h. Level indicator
i. Level adjust
*j. Rider
*k. Chain
l. Rider or chain control arm and handle
m. Zero adjust screws
n. Pointer
o. Pointer scale
p. Gravity adjustment weight
q. Sliding doors
r. Standard weights

*Some balances may have rider or chain or both.

OBJ 2: Demonstrate and explain the use of the major features of a double pan analytical balance.

COND: Given the balance and resources.

PL: Include each of the features in OBJ 1 and explain in your own words.

OBJ 3: Determine the zero point of your balance.

COND: Given the balance and resources.

PL: Zero point should be close enough to the zero on the scale that the pointer may swing freely. Must be reproducible to ± 0.1 unit on the scale.

OBJ 4: State rules for using a balance.

COND: Given the balance, or pictures or sketches of this balance.

PL: Include:

a. Make sure the balance is level.
b. Make sure the balance is zeroed.
c. Lock the beam and pans when objects are added or removed from the pans or beam.

d. Keep balance clean and free of chemicals.
e. Never place hot or cold objects on the pan.
f. Place objects to be weighed near the center of the pan.
g. Clean and dust the pan before and after each weighing.
h. Do not lean on the balance table while weighing.
i. Remove all objects and weights, and lock the pan and beam when weighing is completed.
j. Use the same balance for all comparative weighing.
k. Handle objects carefully to prevent changing weights.

OBJ 5: Weigh a solid object and a liquid sample on the double pan analytical balance.

COND: Given a solid object, a beaker, water, tongs, weighing paper, the balance, and resources.

PL: Weights should be accurate to ± 0.2 mg, and all rules in OBJ 4 should be followed.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES							
	1	2	3	4	5	6	7	8
Double pan analytical balance	x	x	x	x	x			
50 ml beaker or weighing bottle					x			
Water					x			
Solid object or sample of solid chemical					x			
Tongs					x			
Weighing paper					x			
Set of standard weights					x			
Tweezers or forceps					x			
Spatula					x			
Camel's-hair brush				x	x			

Triple Beam and Double Pan Balances

CHEM 101:46f (36)

PURPOSE

This guide will assist you in learning how to use and care for triple beam and double pan balances. These are simple and quick to use and are sufficiently accurate for many routine weighings (those which require accuracy of only 0.1 g or, at most, 0.01 g).

PREREQUISITES

None.

RESOURCES

IRIS: 2911 (Module 17)

OBJECTIVES

OBJ 1: Identify the major features of triple beam and double pan balances.

COND: Given the balances, or pictures or sketches of these balances.

PL: Include:

a. Beams
b. Balance pans
*c. Level indicator
*d. Beam arrest (lock)
e. Pan arrest (lock)
f. Zero adjust
g. Reference weights
h. Pointer
i. Fulcrum (knife edge)
j. Relative precision

*Often not found on these balances.

OBJ 2: State the rules for using a balance.

COND: Given the balances, or pictures or sketches of these balances.

PL: Include:

a. Make sure the balance is level.
b. Make sure the balance is zeroed.
c. Lock the beam and pans when objects are added or removed from the pans or beam.
d. Keep balance clean and free of chemicals.
e. Never place hot or cold objects on the pan.
f. Place objects to be weighed near the center of the pan.
g. Clean and dust the pan before and after each weighing.
h. Do not lean on the balance table while weighing.
i. Remove all objects and weights, and lock the pan and beam when weighing is completed.
j. Use the same balance for all comparative weighing.
k. Handle objects carefully to prevent changing weights.

OBJ 3: Weigh a solid object on the triple beam and double pan balances.

COND: Given an object, the balances, tongs, and resources.

PL: Weights should be accurate to ± 0.1 or ± 0.01 g, depending upon accuracy of the balance. All rules in OBJ 2 should be followed.

OBJ 4: Weigh a liquid sample on the triple beam and double pan balances.

COND: Given a beaker, water, the balances, tongs, and resources.

PL: Weights accurate to ± 0.1 or ± 0.01 g, depending upon the accuracy of the balance. All rules in OBJ 2 should be followed.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES							
	1	2	3	4	5	6	7	8
Triple beam balance	x	x	x	x				
Double pan balance	x	x	x	x				
Tongs			x	x				
250 ml beaker				x				
Solid object or sample or solid chemical (for example, NaCl)			x					
Water				x				
Camel's-hair brush		x	x	x				
Set of reference weights		x	x	x				
Spatula			x					

Electric Single Pan Analytical Balance

Chem 101:46f (36)

PURPOSE

This guide will assist you in learning to use an electric single pan analytical balance. Many tests require accuracy of ± 0.1 mg, which is only possible with analytical balances. The electric single pan analytical balance is expensive, but easy and quick to use.

PREREQUISITES

None.

RESOURCES

IRIS: 2911 (Module 20)

OBJECTIVES

OBJ 1: Identify the major features of an electric single pan analytical balance.

COND: Given the balance, or pictures or sketches of this balance.

PL: Include:

a. Balance pan
b. Level indicator
c. Level adjust
d. Pan arrest
e. Zero adjust
f. Tare adjust
g. Weight control for 100 g, 10 g, 1 g
h. Micrometer control for fractions of grams
i. Optical scales for reading 100 g, 10 g, 1 g, and fractional mg weights
j. Sliding door

OBJ 2: Demonstrate and explain the use of each of the major features of an electric single pan analytical balance.

COND: Given the balance and resources.

PL: Use of each of the features listed in OBJ 1 should be demonstrated and explained.

OBJ 3: Zero an electric single pan analytical balance.

COND: Given the balance and resources.

PL: Zero should be reproducible to ± 0.1 mg.

OBJ 4: State the rules for using a balance.

COND: Given the balance, or pictures or sketches of this balance.

PL: Include:

a. Make sure the balance is level.
b. Make sure the balance is zeroed.
c. Lock the beam and pans when objects are added or removed from the pans or beams.
d. Keep balance clean and free of chemicals.
e. Never place hot or cold objects on the pan.
f. Place objects to be weighed near the center of the pan.
g. Clean and dush the pan before and after each weighing.
h. Do not lean on the balance table while weighing.
i. Remove all objects and weights, and lock the pan and beam when weighing is completed.

j. Use the same balance for all comparative weighing.
k. Handle objects carefully to prevent changing weights.

OBJ 5: Weigh a solid object and a liquid sample on an electric single pan analytical balance.

COND: Given the balance, a solid object, a beaker, water, tongs, weighing paper, and resources.

PL: Weights should be accurate to ± 0.2 mg, and all rules in OBJ 4 should be followed.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES							
	1	2	3	4	5	6	7	8
Electric single pan analytical balance	x	x	x	x	x			
50 ml beaker or weighing bottle					x			
Water					x			
Solid object or sample of solid chemical					x			
Tongs					x			
Weighing paper					x			
Spatula					x			
Camel's-hair brush				x	x			

Laboratory Ovens

ENV SCI 101:1b(49)

PURPOSE

This guide will assist you in learning to operate a laboratory oven for drying glassware, for preparing standard reagents by drying off moisture from their solid forms, and for sterilization. These drying operations at 50°C to 200°C are necessary to give accurate weighings for many tests.

PREREQUISITES

Before beginning this module you should have successfully completed the modules on Balances (Env Sci 101:1a) and Desiccators (Env Sci 101:1c), and you should be able to use a Celsius thermometer [Chem 101:46b(36)].

RESOURCES

IRIS: 2911 (Module 13)

OBJECTIVES

OBJ 1: Identify the major features of a laboratory oven.

COND: Given the oven or photographs or sketches of it.

PL: Include:

a. Temperature control
b. Thermometer or temperature gauge
c. On-off control
d. Door latch
e. Shelving and shelf-adjustment

OBJ 2: Adjust the shelves of an oven for small or large glassware.

COND: Given the oven and several short and tall beakers or flasks.

PL: Glassware should not touch a second shelf, but there should be no more than 5 cm excess height.

OBJ 3: Operate an oven at a given temperature.

COND: Given the oven, the temperature, and resources, including the operations manual for your oven.

PL: Standardize the temperature control settings with a thermometer, then set to ± 1°C using the standard form.

OBJ 4: Add and remove from a hot oven different items of glassware and crucibles.

COND: Given an equipped laboratory and resources.

PL: Use crucible and beaker tongs to prevent burns, spillage, breakage or contamination.

OBJ 5: Heat a solid sample to constant weight in an oven.

COND: Given an equipped laboratory and resources.

PL: Correct weight should be reproduced to ± 1% in 3 consecutive weighings.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES							
	1	2	3	4	5	6	7	8
Drying oven	x	x	x	x	x			
Beaker (250 ml)		x		x				
Erlenmeyer flasks (50 and 125 ml)		x		x				
Tongs				x				
Crucible				x				
Asbestos pad				x	x			
Weighing bottle or 50 ml beaker					x			
Desiccator					x			
Barium chloride ($BaCl_2 \cdot 2H_2O$)					x			

Desiccators

ENV SCI 101:1c(49)

PURPOSE

This guide will assist you in learning how to empty, refill, and lubricate a desiccator and how to handle it to transport hygoscopic substances. The desiccator is used to prevent such samples from picking up water from the atmosphere.

PREREQUISITES

Before beginning this module you should be able to name and use laboratory glassware.

RESOURCES

(To be provided by instructor.)

OBJECTIVES

OBJ 1: Identify and describe the use of the major features of a desiccator.

COND: Given a desiccator or a picture or sketch of a desiccator.

PL: Include the names of two or more desiccants, the techniques for transporting and storing hygoscopic substances, and the purpose of the crucible holder plate.

OBJ 2: Empty, clean, and refill a desiccator with desiccant.

COND: Given the desiccator, clean towels, and the desiccant.

PL: Refilled desiccator should have no adhering particles which could contaminate items to be dried. Desiccant should reach to about 2 cm of the crucible holder plate.

OBJ 3: Clean and regrease the desiccator and lid.

COND: Given an equipped laboratory.

PL: A thin, even layer of grease should give a firm, air-tight seal which does not easily slip.

OBJ 4: Place a hot crucible and lid in the desiccator, and retrieve them when cool.

COND: Given an equipped laboratory.

PL: Crucible lid should be placed beside the crucible, not on it. No contamination should occur from grease or disiccant, and the desiccator lid should be *carefully* removed and replaced to avoid breakage.

OBJ 5: Transport a crucible and lid in a desiccator.

COND: Given a desiccator, crucible, and lid.

PL: Lid must be held firmly and contents not disturbed during transport.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES							
	1	2	3	4	5	6	7	8
Desiccator	x	x	x	x	x			
Desiccant (e.g., silica gel)	x	x	x	x	x			
Towel		x	x					
Solvent (e.g., acetone)			x					
Stopcock grease			x					
Crucible and lid				x	x			
Tongs				x				

Titrations and Standard Solutions

CHEM 101:47f, j (36, 37)

PURPOSE

This guide will help you in learning to perform one of the most basic techniques employed in laboratory work--a titration. To get reliable results from a titration, appropriate standard solutions must be prepared, stored, and used.

PREREQUISITES

Before beginning this module you should have successfully completed Env Sci 101: 2(49) and Chem 101:33(34), 45a,j,l(36), and 46a(36).

RESOURCES

IRIS: 1321 (Chapters 17, 18, 19, 23),
2911 (Modules 22, 23)

OBJECTIVES

OBJ 1: Define the terms:
- a. Titration
- b. Equivalent
- c. Equivalent weight
- d. Standard solution
- e. Primary standard
- f. End-point
- g. Indicator
- h. Meniscus

COND: From recall.

PL: 7 of 8 correct, in the learner's own words.

OBJ 2: Prepare a solution of known concentration.

COND: Given an equipped laboratory, the concentration needed, and a resource.

PL: Solution should be clear, homogeneous, uncontaminated, and within ±10% of the given concentration.

OBJ 3: Standardize the solution prepared in OBJ 2.

COND: Given an equipped laboratory, including the appropriate indicator and primary standard, and instructions for standardization.

PL: Three consecutive titrations should agree to within ±0.2%.

OBJ 4: Determine the concentration of an unknown substance by titration with a standard solution.

COND: Given an equipped laboratory, the standard solution from OBJ 3, and an instruction sheet.

PL: Three consecutive titrations should agree to ±0.2%, and the average should be within ±0.2% of the correct value.

EQUIPMENT AND SUPPLIES

ITEMS	OBJECTIVES 1	2	3	4	5	6	7	8
Beakers (250 ml)		x	x	x				
Erlenmeyer flask (250 ml)		x	x	x				
Volumetric flask (250, 500 or 1000 ml)		x						
Pipet (20 or 25 ml)			x	x				
Buret (50 ml)			x	x				
Primary standard potassium acid phthalate (KHP)			x	x				
Phenolphthalein			x	x				
Sulfuric acid (H_2SO_4)			x	x				
Sodium hydroxide (NaOH)			x	x				

Centrifuge
CHEM 102:26 (61)

PURPOSE

This guide will help you learn to use a centrifuge. The centrifuge is frequently used to separate a heavier layer from a lighter one by forcing the heavier layer (for example, a solid in a liquid) to the bottom of a test tube or centrifuge tube.

PREREQUISITES

None.

RESOURCES

IRIS: 1322 (Chapters 7 and 23)

OBJECTIVES

OBJ 1: Identify the following features of a centrifuge:
- a. On-off switch
- b. Tube-holders
- c. Centrifuge tubes

COND: Given a centrifuge or a sketch or photograph of a centrifuge.

PL: 100% correct.

OBJ 2: Define these terms:
- a. Decant
- b. Decantate
- c. Precipitate
- d. Centrifugate
- e. Supernatant

COND: Given an instruction sheet describing a lab test which uses the terms above.

PL: 100% correct.

OBJ 3: Centrifuge a solid from a mixture with a liquid.

COND: Given an equipped laboratory, a solid slurry, and an instruction sheet.

PL: After centrifuging:
- a. Sample should have a clear liquid above a compacted solid.
- b. Liquid should pour off clearly, leaving a moist solid in the tube.
- c. Solid should be washed twice by stirring with solvent, then recentrifuging and pouring off the liquid.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Centrifuge	x		x					
Centrifuge tubes			x					

(continued)

EQUIPMENT AND SUPPLIES (continued)

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Stirring rod			x					
Beaker (250 ml)			x					
Lead nitrate solution [$Pb(NO_3)_2$]			x					
Sodium chloride solution (NaCl)			x					

Preparation of Buffer Solution

CHEM 102:27e (62)

PURPOSE

This guide will help you learn how to prepare buffer solutions for use in chemical tests and for standardization of a pH meter. The pH meter is frequently used in laboratory tests. To give accurate readings, the pH meter must be standardized against buffers of known pH. These buffers can be prepared more cheaply than purchased, and it may be necessary to prepare a buffer quickly for a specific test or for standardizing the pH meter.

PREREQUISITES

Before beginning this module you should have successfully completed Chem 101:45a, j,1(36) and 47f,j(37).

RESOURCES

IRIS: 1321 (Chapter 23), 1322 (Chapters 6-10), 2153, 2911 (Modules 22, 23)

OBJECTIVES

OBJ 1: Define these terms:

a. Acid (weak and strong)
b. Base (weak and strong)
c. Equilibrium
d. pH
e. Equilibrium constant
f. Common ion
g. Common ion effect

COND: From recall.

PL: 100% correct.

OBJ 2: Calculate the concentration of weak acid and salt (or weak base and salt) required to give a solution of known pH.

COND: Given the equilibrium constants of all weak acids and bases available.

PL: Calculations should be correct in two consecutive tries.

OBJ 3: Prepare a buffer solution of known pH.

COND: Given an equipped laboratory, the pH desired, an instruction sheet, and the concentrations and equilibrium constants of all weak acids and bases available.

PL: pH of the solution should be within ± of 0.3 pH units of that assigned.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES							
	1	2	3	4	5	6	7	8
pH meter			x					
Beakers (250 ml)			x					
Acetic acid ($HC_2H_3O_2$)			x					
Sodium acetate ($NaC_2H_3O_2$)			x					
Ammonia (NH_4OH)			x					
Ammonium chloride (NH_4Cl)			x					
Standard buffers, pH 3, 7, 10			x					

Biochemical Oxygen Demand (BOD)

ENV SCI 102(1):1-8(69-71)

PURPOSE

This guide will assist you in determining the biochemical oxygen demand (BOD) of any water or wastewater. The BOD test is widely used to:

1. measure the dissolved oxygen that would be consumed if a wastewater were discharged into a natural body of water;
2. measure the efficiency of a wastewater process by determining how much BOD it removes;
3. measure the BOD of a natural stream.

PREREQUISITES

Before beginning this module you should have successfully completed DISSOLVED OXYGEN (DO), Env Sci 102(2):1-8(69-71).

RESOURCES

IRIS: 4, 540, 1413, 2558, 2559
NPDES
"Methods for Chemical Analysis of Water and Wastes" (IRIS number not yet assigned).

OBJECTIVES

OBJ 1: Describe and demonstrate the procedures for the preparation of containers for BOD samples.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of the sample containers must meet the specifications in IRIS 4, including that no beads of water or stains will be evident.

OBJ 2: Select appropriate BOD sample location in a wastewater treatment plant or on a watercourse.

COND: Given resources (IRIS 4), wastewater treatment plant operational guide or watercourse map, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Include:

a. Location in plant
b. Location in process unit or stream
c. Depth
d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedures for collecting a BOD sample.

COND: Given the nature of the sample (grab, composite), resources (IRIS 4), the location, and the necessary equipment and supplies.

PL: 90% of the samples must be taken in conformance with procedures in IRIS 4, including:

a. Depth
b. Sampling equipment needed
c. Time of day
d. Frequency (retention time considered)
e. Absence of floating matter

f. Collection of a representative sample
g. Labeling of container to show date, place, time, and name of person who collected sample

OBJ 4: Describe and demonstrate the procedure for transporting a BOD sample to the laboratory.

COND: Given resources (IRIS 4) and the interval up to 6 hours from the time of sampling to time of analysis.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures prescribed in IRIS 4, including:

a. Control of temperature
b. Exclusion of light
c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing a BOD sample.

COND: Given resources (IRIS 4) and the interval up to 6 hours during which the sample must be kept in the laboratory.

PL: 95% of the samples stored must be prepared according to IRIS 4 and must be suitable for analysis after the prescribed storage time.

OBJ 6: Describe and perform a BOD analysis, including proper safety procedure.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of samples must fall within reasonable limits of deviation as defined in IRIS 4. Safety procedures must be followed 100% of the time. Following items must be included:

a. List the following reagents and state their use in the sequence of the analysis:
   1. potassium dihydrogen phosphate
   2. dipotassium hydrogen phosphate
   3. disodium hydrogen phosphate heptahydrate
   4. ammonium chloride
   5. magnesium sulfate heptahydrate
   6. anhydrous calcium chloride
   7. ferric chloride hexahydrate
   8. concentrated sulfuric acid
   9. potassium dichromate
b. List this equipment:
   1. trip balance
   2. still
   3. incubator
c. List these analytical supplies:
   1. glass stoppered bottles
   2. weighing boats
   3. 3-liter jug
   4. plunger type mixer
   5. beakers
   6. graduated cylinders
   7. volumetric flasks
   8. pipets
d. Describe routine procedures for recording data.
e. Describe the calculations (in mg/l) for BOD content.
f. Prepare and standardize the necessary reagents.
g. Describe safety procedures.
h. Determine the BOD content of each sample provided.

OBJ 7: Report and interpret the BOD results using established technical report form.

COND: Given resources (IRIS 4) and typical BOD curves and data.

PL: 90% of results must be correct and 80% of interpretation must conform to those in resources. The results must be interpreted by performing the following:

a. Calculate the BOD for each day.
b. Plot a graph of BOD (mg/l) versus time (days) for each dilution and use it to estimate the best value for BOD_5 for that dilution.
c. Calculate the efficiency of the wastewater process in its removal of BOD.
d. Evaluate the technique using the standard BOD solution in IRIS 4.

OBJ 8: Recognize an abnormal condition in any of the analyses and suggest and take corrective action necessary to correct the abnormal condition.

COND: Given laboratory control guide for plant in question, typical BOD curves and data, laboratory logbooks, and a calculator.

PL: 80% of abnormal conditions must be spotted and corrected, including interferences resulting from:
a. Oxidizing agents
b. Reducing agents
c. Nitrates
d. Organic compounds
e. Ferric salts
f. Suspended solids
g. Highly colored waters

Include:
a. Compare two values for the BOD_5 of the influent.
b. Compare two values for the BOD_5 of the effluent.
c. Justify BOD_5 values.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Air incubator or water bath (20°C)						x		
Dissolved oxygen apparatus						x		
BOD bottles (24 250ml)						x		
Dissolved oxygen reagents						x		
Distilled water						x		
Sealed bottles (2 500ml)	x	x	x		x	x		
Air pump or source of oil free						x		
Compressed air source with bubbler tube						x		
16-gallon nalgene container						x		

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Sample carrier				x				
Refrigerator				x		x		
Potassium dihydrogen phosphate (KH_2PO_4)						x		
Dipotassium hydrogen phosphate ($K_2H\ PO_4$)						x		
Disodium hydrogen phosphate ($Na_2HPO_4 \cdot 7H_2O$)						x		
Ammonium chloride (NH_4Cl)						x		
Magnesium sulfate ($MgSO_4 \cdot 7H_2O$)						x		
Calcium chloride ($CaCl_2$)						x		
Ferric chloride ($FeCl_3 \cdot 6H_2O$)						x		
Sodium hydroxide (NaOH)						x		
Hydrochloric acid (HCl)						x		
Sodium bisulfite ($NaHSO_3$)				x	x	x		

Dissolved Oxygen (DO)

ENV SCI 102 (2):1-8(69-71)

PURPOSE

This guide will assist you in determining the dissolved oxygen level (DO) of any water or wastewater. The dissolved oxygen determination is one of the most important tests in water quality control because:

1. it serves as the basis of the biochemical oxygen demand (BOD) test which measures the oxygen demand of organic material in water;
2. it tells how much dissolved oxygen is available for the respiration of the organisms in the water.

PREREQUISITES

Before beginning this module you should have successfully completed Chem 101:46e, f(36) and 47j(37).

RESOURCES

IRIS: 4, 540, 1413, 2558, 2559
NPDES
"Methods for Chemical Analysis of Water and Wastes" (IRIS number not yet assigned).

OBJECTIVES

OBJ 1: Describe and demonstrate the procedures for the preparation of containers for DO samples.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of the sample containers must meet the specifications in IRIS 4, including that no beads of water or stains will be evident.

OBJ 2: Select appropriate DO sample location in a wastewater treatment plant or on a watercourse.

COND: Given resources (IRIS 4), wastewater treatment plant operational guide or watercourse map, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Selection must include:

a. Location in plant
b. Location in process unit or stream
c. Depth
d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedures for collecting a DO sample.

COND: Given resources (IRIS 4), the location, and the necessary equipment and supplies.

PL: 90% of the samples taken must be taken in conformance with procedures in IRIS 4, including:

a. Depth
b. Sampling equipment needed
c. Time of day
d. Frequence
e. Absence of floating material
f. Collection of a representative sample

g. Labeling of container to show date, time, and name of person who collected sample

OBJ 4: Describe and demonstrate the procedure for transporting a DO sample to the laboratory.

COND: Given resources (IRIS 4) and the interval from time of sampling to time of analysis, usually less than 30 minutes.

PL: 95% of samples arriving at the laboratory must be suitable for analysis in conformance with procedures described in IRIS 4, including:

a. Control of temperature
b. Exclusion of light
c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing a DO sample.

COND: Given resources (IRIS 4) and the time interval over which the sample must be kept in the laboratory, usually less than 30 minutes.

PL: 95% of the samples stored must be suitable for analysis after the prescribed storage time.

OBJ 6: Describe and perform a DO analysis, including proper safety procedure.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of samples must fall within reasonable limits of deviation as defined in IRIS 4. Safety procedures must be followed 100% of the time. The following items must be included:

a. List the following reagents and explain their roles in the analysis:
   1. manganous sulfate solution
   2. alkali-iodide-azide reagent
   3. concentrated sulfuric acid
   4. starch solution
   5. standard sodium thiosulfate titrant, 0.0250N
   6. standard potassium dichromate solution, 0.0250N
   7. potassium iodide, crystals
   8. potassium fluoride solution
b. List this equipment:
   1. analytical balance
   2. water still
c. List these analytical supplies:
   1. volumetric flasks
   2. beakers
   3. BOD bottles with stoppers, 300 ml
   d. burets
   5. buret support, clamps and caps
   6. pipets
   7. graduated cylinders
d. Explain the titration procedure and describe the end point.
e. Describe routine procedures for recording data.
f. Describe the calculations (in mg/l) for dissolved oxygen content.
g. Prepare and standardize the necessary reagents.
h. Describe safety procedures.
i. Determine the DO content of each sample provided using the iodometric method.

OBJ 7: Report and interpret the DO results using established technical report form.

COND: Given resources (IRIS 4).

PL: 90% of results must be correct, and 80% of interpretations must conform to those in resources. Results must be interpreted by:

a. Calculating the DO for each sample.

b. Comparing the DO with results of other groups performing the same analysis.
c. Explaining why any disagreement in results might occur.

OBJ 8: Recognize an abnormal condition in any of the analyses and suggest and take corrective action necessary to correct the abnormal condition.

COND: Given resources (IRIS 4), laboratory control guide for plant in question, typical DO data, laboratory notebooks, and a calculator.

PL: 80% of abnormal conditions must be spotted and corrected, including interferences resulting from:
a. Oxidizing agents
b. Reducing agents
c. Nitrates
d. Organic compounds
e. Ferric salts
f. Suspended solids
g. Highly colored waters

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES							
	1	2	3	4	5	6	7	8
Buret						x		
Buret clamp						x		
Ring stand						x		
Funnel						x		
200 ml volumetric flask						x		
Analytical balance						x		
1 liter volumetric flask			x					
1 liter beaker (2)			x					
Filter paper			x					
500 ml Erlenmeyer flask						x		
10 ml graduated cylinder			x					
BOD bottles (4 250 ml)	x	x	x					
Stirring rod			x					

EQUIPMENT AND SUPPLIES (continued)

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Hot plate			x					
Distilled water			x					
Sample carrier				x				
Manganese sulfate ($MnSO_4 \cdot 4H_2O$ or $MnSO_4 \cdot 2H_2O$ or $MnSO_4 \cdot H_2O$)			x					
Sodium hydroxide (NaOH or KOH)			x					
Sodium iodide (NaI or KI)			x					
Sodium azide (NaN_3)			x					
Concentrated sulfuric acid (H_2SO_4)			x					
Starch ($C_6H_{10}O_5$)						x		
Sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$)						x		
Potassium dichromate ($K_2Cr_2O_7$)						x		
Potassium fluoride ($KF \cdot 2H_2O$)						x		
Toluene (C_7H_8)			x					

Chemical Oxygen Demand (COD)

ENV SCI 102(3):1-8(69-71)

PURPOSE

This guide will assist you in determining the chemical oxygen demand (COD) of any water or wastewater. The COD test measures the total organic content that can be oxidized (usually to carbon dioxide and water) by potassium dichromate in a sulfuric acid solution. The main limitations of COD are that it does not reveal whether the organic matter is biodegradable or nonbiodegradable, and it gives no idea of the rate at which biologically active material (waste) would be stabilized in a receiving stream. These limitations are often compensated for by the fact that COD will always be greater than or equal to BOD and may be run in 3 hours as compared to the 5 days required by BOD.

PREREQUISITES

Before beginning this module you should have successfully completed Chem 101:46e, f(36) and 47f,j(36-37); and Env Sci 101: 1e(49).

RESOURCES

IRIS: 4, 539, 557, 2558, 2559
"Methods for Chemical Analysis of Water and Wastes" (IRIS number not yet assigned).

OBJECTIVES

OBJ 1: Describe and demonstrate the procedures for the preparation of containers for COD samples.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of the sample containers must meet the specifications in IRIS 4, including that no beads of water or stains will be evident.

OBJ 2: Select appropriate COD sample location in a wastewater treatment plant or on a watercourse.

COND: Given resources (IRIS 4), wastewater treatment plant operational guide or watercourse map, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Include:

a. Location in plant
b. Location in process unit or stream
c. Depth
d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedures for collecting a COD sample.

COND: Given the nature of the sample (grab, composite), resources (IRIS 4), the location, and the necessary equipment and supplies.

PL: 90% of the samples taken must be taken in conformance with procedures in IRIS 4, including:

a. Depth
b. Sampling equipment needed

c. Time of day
d. Frequency
e. Absence of floating matter
f. Collection of a representative sample
g. Labeling of container to show date, place, time, and name of person who collected sample

OBJ 4: Describe and demonstrate the procedure for transporting a COD sample to the laboratory.

COND: Given resources (IRIS 4) and the interval (up to 7 days) from the time of sampling to time of analysis.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures prescribed in IRIS 4, including:

a. Control of temperature
b. Exclusion of light
c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing a COD sample.

COND: Given resources (IRIS 4) and the interval (up to 7 days) over which the sample must be kept in the laboratory.

PL: 95% of the samples stored must be suitable for analysis after the prescribed storage time.

OBJ 6: Describe and perform a COD analysis, including proper safety procedures.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of samples must fall within reasonable limits of deviation, as defined in IRIS 4. Safety procedures must be followed 100% of the time.

Include:

a. Prepare or obtain a list of chemicals, equipment, and analytical supplies needed to perform the dichromate method for COD analysis.
b. Describe the safety procedures for preparing silver sulfate-sulfuric acid solution.
c. Explain how these safety precautions protect the employee.
d. Name the two major steps in the dichromate procedure (refluxing and titration).
e. Describe the end point in the titration procedure.
f. Describe the routine procedures for recording data.
g. Set up equipment for titration.
h. Prepare and standardize the reagents.
i. Describe safety procedures.
j. Prepare a sample and a blank for the reflux condenser.
k. Perform the dichromate titration for COD analysis on a sample from one of the plant locations and report for the blank.
l. Record data and calculate the COD for each sample.

OBJ 7: Report and interpret the COD results using established technical report form.

COND: Given resources (IRIS 4) and typical COD curves and data.

PL: 90% of results must be correct and 80% of interpretation must conform to those in resources. The results must be interpreted by:

a. Calculating the COD for each sample.
b. Comparing the COD with results of other groups performing the same analysis.

c. Explaining why any disagreement in results might occur.

OBJ 8: Recognize an abnormal condition in any of the analyses and suggest and take corrective action necessary to correct the abnormal condition.

COND: Given laboratory control guide for plant in question, typical COD curves and data, laboratory logbooks, and a calculator.

PL: 80% of abnormal conditions must be spotted and corrected, including interferences resulting from:

a. Aromatic hydrocarbon
b. Chlorides
c. Fatty acids
d. Ferrous iron
e. Nitrates
f. Pyridine
g. Sulfides

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Erlenmeyer flask (24/40 250ml)						x		
Buret						x		
Liebig condenser (24/40 joint)						x		
Hot plate						x		
Glass boiling beads						x		
500ml bottle (2)	x	x						
Volumetric flask (1 liter)						x		
Sample carrier				x				
Sulfuric acid (H_2SO_4)						x		
Potassium dichromate ($K_2Cr_2O_7$)						x		
Silver sulfate (Ag_2SO_4)						x		
Ferrous ammonium sulfate [$Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$]						x		
Mercuric sulfate ($HgSO_4$)						x		
Sulfamic acid						x		
1-10-phenanthroline monohydrate						x		

Total Dissolved Solids, Total Suspended Solids, Total Volatile Solids, and Total Solids

ENV SCI 102(4-7):1-8(69-71)

PURPOSE

This guide will assist you in performing four different solids tests on any water or wastewater. The solids tests measure the total amount of solid that may be found in any water sample and classify them according to whether they are dissolved, suspended or volatile. Solids in waters can cause an unpleasant taste and might produce sickness in people who are not accustomed to drinking them. The main limitations of the four solids tests are:

1. obtaining a representative sample;
2. difficulty of drying to constant weight in a reasonable time, especially when solids are high in oil or grease;
3. losses of volatile materials and carbon dioxide during muffle furnace ignition;
4. losses of volatile compounds during evaporation.

PREREQUISITES

Before beginning this module, you should have successfully completed Chem 101:46b, f(36) and 47a,j(36-37); and Env Sci 101: 1a,b,c,d(49).

RESOURCES

IRIS: 4, 902, 1370, 2559
"Methods for Chemical Analysis of Water and Wastes" (IRIS number not yet assigned).

OBJECTIVES

OBJ 1: Describe and demonstrate the procedures for the preparation of containers for RESIDUE (SOLIDS) ANALYSIS samples.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of the sample containers must meet the specifications in IRIS 4, including that no beads of water or stains will be evident.

OBJ 2: Select appropriate RESIDUE (SOLIDS) ANALYSIS sample location in a wastewater treatment plant or on a watercourse.

COND: Given resources (IRIS 4), wastewater treatment plant operational guide or watercourse map, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Include:

a. Location in plant
b. Location in process unit or stream
c. Depth
d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedures for collecting a RESIDUE (SOLIDS) ANALYSIS sample.

COND: Given the nature of the sample (grab, composite), resources (IRIS 4), the location, and the necessary equipment and supplies.

PL: 90% of the samples taken must be taken in conformance with procedures in IRIS 4, including:

a. Depth
b. Sampling equipment needed
c. Time of day
d. Frequency
e. Removal of floating matter
f. Collection of a representative sample
g. Labeling of container to show date, place, time, and name of person who collected sample

OBJ 4: Describe and demonstrate the procedure for transporting a RESIDUE (SOLIDS) ANALYSIS sample to the laboratory.

COND: Given resources (IRIS 4) and the interval (up to 7 days) from time of sampling to time of analysis.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures described in IRIS 4, including:

a. Control of temperature
b. Exclusion of light
c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing a RESIDUE (SOLIDS) ANALYSIS sample.

COND: Given resources (IRIS 4) and the interval (up to 7 days) during which the sample must be kept in the laboratory.

PL: 95% of the samples stored must be suitable for analysis after the prescribed storage time.

OBJ 6: Describe and perform each one of four RESIDUE (SOLIDS) ANALYSES, including proper safety procedure.

COND: Given resources (IRIS 4), and an equipped laboratory.

PL: 90% of samples must fall within reasonable limits of deviation as defined in IRIS 4. Safety procedures must be followed 100% of the time.

Include:

a. List the equipment appropriate to the solids test performed:
   1. balances
   2. muffle furnace
   3. crucible tongs
   4. desiccator
   5. gooch crucible
   6. gravity oven
   7. steambath
b. List these analytical supplies:
   1. evaporating dish
   2. glass filter disk
   3. suction flask
   4. crucible holder
   5. wash bottle
   6. graduated cylinders
c. Describe routine procedures for recording data.
d. Describe safety procedures.
e. Describe the calculations (in mg/l) for solids content.
f. Determine the solids content of each sample.

OBJ 7: Report and interpret the RESIDUE (SOLIDS) ANALYSIS using established technical report form.

COND: Given resources (IRIS 4).

PL: 90% of results must be correct and 80% of interpretation must conform to those in resources. The results must be interpreted by:

a. Calculating TS, TDS, TVS, and TSS values.
b. Comparing the values with the results of other groups performing the same analysis.
c. Explaining why any disagreement in results might occur.

OBJ 8: Recognize an abnormal condition in any of the analyses and suggest and take corrective action necessary.

COND: Given resources (IRIS 4).

PL: 80% of abnormal conditions must be spotted and corrected, including errors resulting from:

a. Volatile compounds lost during evaporation.
b. Carbon dioxide lost during ignition.
c. Calcium oxide produced during ignition and remaining in the ash.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Analytical balance						x		
Muffle furnace (550°C)						x		
Crucible tongs						x		
Desiccator						x		
Gravity oven (105°C)						x		
Steam bath						x		
Evaporating dish (50 ml)						x		
Glass filter disk (2.1 cm)						x		
Suction flask (500 ml)						x		
Crucible holder						x		
Wash bottle						x		
Graduated cylinder (50 ml)						x		
Graduated cylinder (100 ml)						x		
1 liter bottle	x		x					
Sample carrier				x				
Gooch crucible						x		

Residual Chlorine and Chlorine Demand

ENV SCI 102(8):1-8(69-71)

PURPOSE

This guide will assist you in determining the residual chlorine and the chlorine demand of a water sample. The residual chlorine test is widely used to:

1. calculate the chlorine demand;
2. calculate the proper amount of chlorine to apply so as to insure effective disinfection without waste of chlorine;
3. estimate the type of chlorination equipment needed by a water facility.

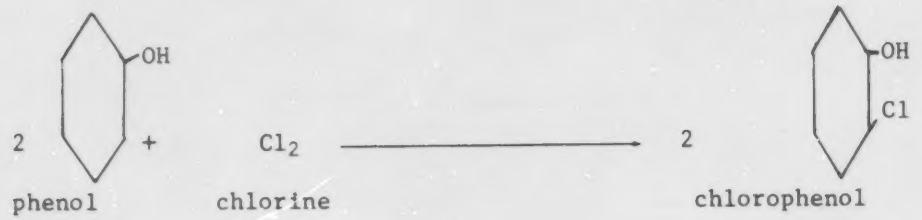
Chlorine is typically applied in the form of free chlorine or calcium hypochlorites. These forms of chlorine are strong oxidizing agents, and they react with a wide variety of impurities and substances in water. Side reactions of this type use up much of the chlorine before it can accomplish the disinfection intended. Chlorine demand is defined as the amount of chlorine necessary to satisfy the demand of various substances and impurities in water before actual disinfection can take place. The equations below indicate some of these demands:

NH_3 (ammonia) + HOCl (hypochlorous acid) → NH_2Cl (monochloramine) + H_2O

NH_2Cl (monochloramine) + HOCl (hypochlorous acid) → $NHCl_2$ (dichloramine) + H_2O

$NHCl_2$ (dichloramine) + HOCl (hypochlorous acid) → NCl_3 (trichloramine) + H_2O

H_2S (hydrogen sulfide) + $4Cl_2$ (chlorine) + H_2O → H_2SO_4 (sulfuric acid) + 8HCl (hydrochloric acid)



phenol — chlorine — chlorophenol

Studies indicate that the chloramines (also called combined chlorine residuals) are capable of some disinfection, although they are not as effective as the free chlorine residuals (Cl_2, HOCl, and OCl^-). The chlorine demand of a water sample is found by subtracting the total residual chlorine (both free and combined) from the amount of chlorine applied.

PREREQUISITES

Before beginning this module you should have successfully completed Chem 101:46e, f(36) and 47f,j(36-37).

RESOURCES

IRIS: 4, 142, 556, 2558, 2559
"Methods for Chemical Analysis of Water and Wastes" (IRIS number not yet assigned).

OBJECTIVES

OBJ 1: Describe and demonstrate the procedures for the preparation of containers for residual chlorine samples.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of the sample containers must meet the specifications in IRIS 4, including that no beads of water or stains will be evident.

OBJ 2: Select appropriate residual chlorine sample location in a wastewater treatment plant or on a watercourse.

COND: Given resources (IRIS 4), wastewater treatment plant operational guide or watercourse map, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Include:
a. Location in plant
b. Location in process unit or stream
c. Depth
d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedures for collecting a residual chlorine sample.

COND: Given the nature of the sample (grab, composite), resources (IRIS 4), the location, and the necessary equipment and supplies.

PL: 90% of the samples taken must be taken in conformance with procedures in IRIS 4, including:
a. Depth
b. Sampling equipment needed
c. Time of day
d. Frequency (retention time considered)
e. Absence of floating matter
f. Collection of a representative sample
g. Labeling of container to show date, place, time and name of person who collected sample

OBJ 4: Describe and demonstrate the procedure for transporting a residual chlorine sample to the laboratory.

COND: Given resources (IRIS 4), and the proper interval from time of sampling to time of analysis.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis

in conformance with procedures prescribed in IRIS 4, including:

a. Control of temperature
b. Exclusion of light
c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing a residual chlorine sample.

COND: Given resources (IRIS 4) and the proper interval over which the sample may be kept in the laboratory.

PL: 95% of the samples stored must be suitable for analysis after the prescribed storage time.

OBJ 6: Describe and perform a residual chlorine and chlorine demand analysis, including proper safety procedure.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of the samples must fall within reasonable limits of deviation as defined in IRIS 4. Safety procedures must be followed 100% of the time.

Include:

a. List the following reagents and explain their roles in the analysis:
   1. standard sodium thiosulfate
   2. potassium dichromate
   3. potassium iodide
   4. acetic acid
   5. sulfuric acid
   6. starch
   7. sodium arsenite
   8. ammonium solution
b. List this equipment:
   1. water still
   2. pH meter
   3. analytical balance
c. List these analytical supplies:
   1. brown glass reagent bottles
   2. volumetric flasks
   3. burets and buret caps
   4. pipets and pipet bulb
   5. Erlenmeyer flasks
   6. graduated cylinders
d. Prepare and standardize the necessary reagents.
e. Describe safety procedures.
f. Determine the chlorine content of each sample provided using the starch-iodide method.

OBJ 7: Report and interpret the residual chlorine and chlorine demand results using established technical report form.

COND: Given resources (IRIS 4) and the amount of chlorine applied.

PL: 90% of results must be correct and 80% of interpretations must conform to those in resources. The results must be interpreted by:

a. Calculating the residual chlorine for each sample.
b. Calculating the chlorine demand for each sample.
c. Comparing these values with acceptable values.

OBJ 8: Recognize an abnormal condition in any of the analyses and suggest and take corrective action necessary to correct the abnormal condition.

COND: Given laboratory control guide for plant in question, laboratory logbooks, and a calculator.

PL: 80% of abnormal conditions must be spotted and corrected, including interferences resulting from:

a. Ferric ion
b. Manganese ion
c. Nitrite ion
d. Color and turbidity

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
500 ml Erlenmeyer flasks (2)		x	x			x		
50 ml buret						x		
Analytical balance						x		
Single pan balance						x		
Sample carrier	x	x	x	x				
Starch						x		
Potassium iodide (KI)						x		
Sodium thiosulfate ($Na_2S_2O_3$)						x		
Potassium dichromate ($K_2Cr_2O_7$)						x		
Iodine (I_2 resublimed)						x		
Acetic acid (glacial)						x		

Nitrogen (Organic)

ENV SCI 102(10):1-8(69-71)

PURPOSE

This guide will assist you in determining the organic nitrogen in drinking, surface, and saline waters, and domestic and industrial wastes. The organic nitrogen is determined by subtracting the nitrogen (ammonia) value [Env Sci 102(12):1-8(69-71)] from the Kjeldahl nitrogen value [Env Sci 102(11):1-8(69-71)].

PREREQUISITES

Before beginning this guide you should have successfully completed Chem 102(57); Env Sci 101:1,2(49); Env Sci 102(12):1-8 (69-71); and Env Sci 102(11):1-8(69-71).

RESOURCES

IRIS: 4
"Methods for Chemical Analysis of Water and Wastes" (IRIS number not yet assigned).

OBJECTIVES

OBJ 1: Calculate the organic nitrogen by subtracting the nitrogen (ammonia) value [Env Sci 102(12):1-8(69-71)] from the Kjeldahl nitrogen value [Env Sci 102 (11):1-8(69-71)].

COND: Given the data from the nitrogen (ammonia) and Kjeldahl nitrogen test.

PL: Three consecutive correct values must be obtained.

EQUIPMENT AND SUPPLIES

None

Kjeldahl Nitrogen

ENV SCI 102(11):1-8(69-71)

PURPOSE

This guide will assist you in determining the total Kjeldahl nitrogen in drinking, surface, and saline waters, and domestic and industrial wastes. The Kjeldahl method destroys the organic portion of nitrogen compounds by oxidation and frees the nitrogen as ammonia. This ammonia, along with any free ammonia already present in the sample, is measured by Nesslerization, or by titrimetry or potentiometrically. A disadvantage of the method is that it might not completely oxidize such industrial wastes as amines, nitro compounds, hydrazones, oximes, semicarbazones, and some refractory tertiary amines.

PREREQUISITES

Before beginning this module you should have successfully completed Chem 102(57) and Env Sci 101:1,2(49).

RESOURCES

IRIS: 4
"Methods for Chemical Analysis of Water and Wastes" (IRIS number not yet assigned).

OBJECTIVES

OBJ 1: Describe and demonstrate the procedure for the preparation of containers for Kjeldahl nitrogen samples.

COND: Given resources (IRIS 4) and an equipped wastewater laboratory.

PL: 100% of the sample containers must meet the specifications in IRIS 4, including no beads of water will be evident.

OBJ 2: Select appropriate Kjeldahl nitrogen sample location in a wastewater treatment plant or on a watercourse.

COND: Given resources (IRIS 4), wastewater treatment plant operational guide or watercourse map, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Selection must include:

a. Location in plant
b. Location in process unit or stream
c. Depth
d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedures for collecting a Kjeldahl nitrogen sample.

COND: Given the nature of the sample (grab, composite), resources (IRIS 4), the location, and the necessary equipment and supplies.

PL: 100% of the samples must be taken in conformance with procedures in IRIS 4, including:

a. Depth
b. Sampling equipment needed
c. Time of day

d. Frequency (retention time considered)
e. Absence of floating matter
f. Collection of a representative sample
g. Labeling of containers to show date, place, time, and name of person who collected sample

OBJ 4: Describe and demonstrate the procedure for transporting a Kjeldahl nitrogen sample to the laboratory.

COND: Given resources (IRIS 4) and the interval (as soon as possible, but up to 7 days) from time of sampling to time of analysis.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures prescribed in IRIS 4, including:

a. Control of temperature
b. Exclusion of light
c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing a Kjeldahl nitrogen sample.

COND: Given resources (IRIS 4) and the time interval (as soon as possible, but up to 7 days) over which the sample must be kept in the laboratory.

PL: 95% of the samples stored must be suitable for analysis after the prescribed storage time.

OBJ 6: Describe and perform a Kjeldahl nitrogen analysis, including proper safety procedure.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of samples must fall within reasonable limits of deviation as defined in IRIS 4. Safety procedures must be followed 100% of the time.

Include:

a. List this equipment:
   1. Kjeldahl digestion apparatus
   2. ion exchange column
   3. pH meter
   4. spectrophotometer
b. List these analytical supplies:
   1. Kjeldahl flask (800 ml)
   2. condenser
   3. condenser adapter
   4. glass beads
   5. volumetric flasks (500 ml and 1 liter
   6. Erlenmeyer flask (500 ml)
   7. graduated cylinders (100 ml and 500 ml)
c. Describe routine procedures for recording data.
d. Describe safety procedures.
e. Describe the calculations [in TKN (mg/l)] for Kjeldahl nitrogen.
f. Determine the Kjeldahl nitrogen for each sample.

OBJ 7: Report and interpret the Kjeldahl nitrogen results using established technical report form.

COND: Given resources (IRIS 4).

PL: 90% of results must be correct and 80% of interpretation must conform to those in IRIS 4. Results will be interpreted by:

a. Calculating the TKN.
b. Comparing the value with results of other groups performing the same analysis.
c. Explaining why any disagreement in results might occur.

OBJ 8: Recognize an abnormal condition in any of the analyses and suggest and

take corrective action necessary to correct the abnormal condition.

COND: Given resources (IRIS 4), charts, nomographs, standard curves, and laboratory notebooks.

PL: 80% of abnormal conditions must be spotted and corrected, including interferences resulting from:

a. Hydrolysis of glycine, urea, glutamic acid, cyanates and acetamide
b. Ketone
c. Aldehydes
d. Alcohols
e. Amines
f. Chlorine

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Kjeldahl digestion apparatus						x		
Ion exchange column						x		
pH meter						x		
Spectrophotometer						x		
Kjeldahl flask (800 ml)						x		
Condenser						x		
Condenser adapter						x		
Glass beads						x		
Volumetric flasks (500 ml and 1 liter)						x		
Erlenmeyer flask (500 ml)						x		
Graduated cylinders (100 ml and 500 ml)						x		
Sample bottles	x	x	x	x				
Ammonia-free water						x		
Mercuric oxide (H_gO)						x		
Sulfuric acid (H_2SO_4)						x		
Potassium sulfate (K_2SO_4)						x		

EQUIPMENT AND SUPPLIES (Continued)

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Sodium hydroxide (NaOH)						x		
Sodium thiosulfate ($Na_2S_2O_3$)						x		
Phenolphthalein						x		
Ethyl alcohol						x		
Methyl red						x		
Methylene blue						x		
Boric acid (H_3BO_3)						x		
Sodium carbonate (Na_2CO_3)						x		
Ammonium chloride (NH_4Cl)						x		
Mercuric iodide (H_gI_2)						x		
Potassium iodide (KI)						x		

Nitrogen (Ammonia)

ENV SCI 102(12):1-8(69-71)

PURPOSE

This guide will assist you in determining all the nitrogen that exists as the ammonium ion or in the equilibrium equation:

$$NH_4^+ \rightleftharpoons NH_3 + H^+$$

The method, because of the high pH at which it is performed, shifts the equilibrium of the above equation to the right, and the NH_3 is collected in the boric acid absorbing solution. The method is suitable for domestic and industrial wastes, and for drinking, surface, and saline waters.

PREREQUISITES

Before beginning this module you should have successfully completed Chem 102(57) and Env Sci 101:1,2(49).

RESOURCES

IRIS: 4
"Methods for Chemical Analysis of Water and Wastes" (IRIS number not yet assigned).

OBJECTIVES

OBJ 1: Describe and demonstrate the procedure for the preparation of containers for ammonia-nitrogen samples.

COND: Given resources (IRIS 4) and an equipped wastewater laboratory.

PL: 100% of the sample containers must meet the specifications in IRIS 4, including that no beads of water will be evident.

OBJ 2: Select appropriate ammonia nitrogen sample location in a wastewater treatment plant or on a watercourse.

COND: Given resources (IRIS 4), wastewater treatment plant operational guide or watercourse map, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Selection must include:

a. Location in plant
b. Location in process unit or stream
c. Depth
d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedures for collecting an ammonia-nitrogen sample.

COND: Given the nature of the sample (grab, composite), resources (IRIS 4), the location, and the necessary equipment and supplies.

PL: 100% of the samples must be taken in conformance with procedures in IRIS 4, including:

a. Depth
b. Sampling equipment needed
c. Time of day
d. Frequency (retention time considered)
e. Absence of floating matter

f. Collection of a representative sample
g. Labeling of containers to show date, place, time, and name of person who collected sample

OBJ 4: Describe and demonstrate the procedure for transporting an ammonia-nitrogen sample to the laboratory.

COND: Given resources (IRIS 4) and the interval (up to 24 hours) from time of sampling to time of analysis.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures prescribed in IRIS 4, including:

a. Control of temperature
b. Exclusion of light
c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing an ammonia-nitrogen sample.

COND: Given resources (IRIS 4) and the appropriate time interval over which the sample must be kept in the laboratory.

PL: 95% of the samples stored must be suitable for analysis after the prescribed storage time.

OBJ 6: Describe and perform an ammonia-nitrogen analysis, including proper safety procedure.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of samples must fall within reasonable limits of deviation as defined in IRIS 4. Safety procedures must be followed 100% of the time.

Include:

a. List this equipment:
    1. pH meter
    2. spectrophotometer
    3. ion exchange column
b. List these analytical supplies:
    1. Kjeldahl flask (800 ml)
    2. glass beads
    3. condenser
    4. condenser adapter
    5. graduated cylinders (100 ml and 500 ml)
    6. Erlenmeyer flask (500 ml)
    7. Volumetric flasks (500 ml and 1 liter)
c. Describe routine procedures for recording data.
d. Describe safety procedures.
e. Describe the calculations (in mg/l NH_3-N) for ammonia-nitrogen.
f. Determine the ammonia-nitrogen for each sample.

OBJ 7: Report and interpret the ammonia-nitrogen results using established technical report form.

COND: Given resources (IRIS 4).

PL: 90% of results must be correct and 80% of interpretation must conform to those in IRIS 4. Results will be interpreted by:

a. Calculating the ammonia-nitrogen.
b. Comparing the value with results of other groups performing the same analysis.
c. Explaining why any disagreement in results might occur.

OBJ 8: Recognize an abnormal condition in any of the analyses, and suggest and take corrective action necessary to correct the abnormal condition.

COND: Given resources (IRIS 4), charts, nomographs, standard curves, and laboratory notebooks.

PL: 80% of abnormal conditions must be spotted and corrected, including interferences resulting from:

a. Aromatic amines
b. Aliphatic amines
c. Cyanate
d. Ketones
e. Aldehydes
f. Alcohols

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Ion exchange column						x		
pH meter						x		
Spectrophotometer						x		
Kjeldahl flask (800 ml)						x		
Condenser						x		
Condenser adapter						x		
Glass beads						x		
Volumetric flasks (500 ml and 1 liter)						x		
Erlenmeyer flask (500 ml)						x		
Graduated cylinders (100 ml and 500 ml)						x		
Sample bottles	x	x	x	x				
Ammonia-free water						x		
Ammonium chloride						x		
Boric acid (H_3BO_3)						x		
Methyl red						x		
Ethyl alcohol						x		
Methylene blue						x		
Mercuric iodide (H_gI_2)						x		

EQUIPMENT AND SUPPLIES (continued)

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Potassium iodide (KI)						x		
Sodium hydroxide (NaOH)						x		
Sodium tetraborate ($Na_2B_4O_7$)						x		
Sulfuric acid (H_2SO_4)						x		
Sodium carbonate (Na_2CO_3)						x		
Sodium thiosulfate ($Na_2S_2O_3$)						x		

Nitrogen (Nitrate)

ENV SCI 102(13):1-8(69-71)

PURPOSE

This guide will assist you in performing the nitrate test, which is performed for three reasons:

1. it determines the progressive destruction of organic nitrogen and ammonia as they form nitrate in aerobic processes;
2. it tells whether the nitrate level of a water exceeds the 10 mg/l limit set by the U.S. Public Health Service to help prevent the disease methemoglobinemia;
3. it can provide, when combined with other data, a measure of the degree of eutrophication of a water.

PREREQUISITES

Before beginning this module you should have successfully completed Chem 101:46e, f(36) and 47j(37); and Env Sci 101:1i(49).

RESOURCES

IRIS: 4, 480
"Methods for Chemical Analysis of Water and Wastes" (IRIS number not yet assigned).

OBJECTIVES

OBJ 1: Describe and demonstrate the procedures for the preparation of containers for nitrate samples.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of the sample containers must meet the specifications in IRIS 4, including that no beads of water or stains will be evident.

OBJ 2: Select appropriate nitrate sample location in a wastewater treatment plant or on a watercourse.

COND: Given resources (IRIS 4), wastewater treatment plant operational guide or watercourse map, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Include:

a. Location in plant
b. Location in process unit of stream
c. Depth
d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedures for collecting a nitrate sample.

COND: Given the nature of the sample (grab, composite), resources (IRIS 4), the location, and the necessary equipment and supplies.

PL: 90% of the sample taken must be taken in conformance with procedures in IRIS 4, including:

a. Depth
b. Sampling equipment needed
c. Time of day

d. Frequency (retention time considered)
e. Collection of a representative sample
f. Absence of floating matter
g. Labeling of container to show date, place, time, and name of person who collected sample
h. Preservative

OBJ 4: Describe and demonstrate the procedure for transporting a nitrate sample to the laboratory.

COND: Given resources (IRIS 4) and an interval of up to 24 hours from time of sampling to time of analysis.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures prescribed in IRIS 4, including:
a. Control of temperature
b. Exclusion of light
c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing a nitrate sample.

COND: Given resources (IRIS 4) and an interval (up to 24 hours) over which the sample must be kept in the laboratory.

PL: 95% of the samples stored must be suitable for analysis after the prescribed storage time.

OBJ 6: Describe and perform a nitrate analysis, including proper safety procedure.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of samples must fall within reasonable limits of deviation as defined in IRIS 4. Safety procedures must be followed 100% of the time.
Include:
a. List the following reagents and explain their roles in the analysis:
1. anhydrous potassium nitrate
2. sodium arsenite
3. brucine sulfate
4. sulfuric acid
5. sulfanilic acid
6. sodium chloride
b. List this equipment:
1. spectronic 20
2. pH meter
3. balance
4. water bath
c. List these analytical supplies:
1. bottles
2. volumetric flasks
3. spectrophotometer tubes
4. test tubes
5. pipet
6. beaker
d. Describe routine procedure for recording data.
e. Describe the calculations (in mg/l) for nitrate.
f. Prepare and standardize the necessary reagents.
g. Describe safety procedures.
h. Determine the nitrate content of each sample.

OBJ 7: Report and interpret the nitrate results using established technical report form.

COND: Given resources (IRIS 4).

PL: 90% of results must be correct and 80% of interpretation must conform to those in resources. The results will be interpreted by:
a. Obtaining a standard curve by plotting the absorbance of standards (minus the absorbance of their corresponding "blanks" without brucine sulfate) against mg NO_3 - N/l.

b. Subtracting the absorbance of the "blank" sample from the absorbance of the sample, and using this value and the standard curve to determine the concentration of NO_3 - N.
c. Comparing the nitrate concentration with results of other groups performing the same analysis.
d. Explaining why any disagreement in results might occur.

OBJ 8: Recognize an abnormal condition in any of the analyses and suggest and take corrective action necessary to correct the abnormal condition.

COND: Given resources (IRIS 4).

PL: 80% of abnormal conditions must be spotted and corrected, including interferences resulting from:

a. Strong oxidants
b. Strong reductants
c. Residual chlorine
d. Iron
e. Nitrate
f. Chloride
g. High concentrations of organic matter

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES							
	1	2	3	4	5	6	7	8
500 ml bottles (2)	x	x	x	x	x			
Spectrophotometer (410 nm)						x		
1 liter volumetric flask						x		
200 ml volumetric flask						x		
100 ml volumetric flask						x		
10 ml volumetric flask						x		
30 ml test tubes (12)						x		
Test tube rack						x		
Spectrophotometer tubes						x		
Analytical balance						x		
10 ml pipet						x		
pH meter						x		

EQUIPMENT AND SUPPLIES (continued)

ITEM	OBJECTIVES							
	1	2	3	4	5	6	7	8
Cold water bath (0-10°C)						x		
Hot water bath (100°C)						x		
Graph paper							x	x
Sample carrier				x				
Anhydrous potassium nitrate (KNO_3)						x		
Sodium arsenite (NaA_5O_2)						x		
Brucine sulfate						x		
Hydrochloric acid (conc. HCl)						x		
Sulfanilic acid						x		
Sulfuric acid (conc. H_2SO_4)						x		
Sodium chloride (NaCl)						x		

Nitrogen (Nitrite)

ENV SCI 102(14):1-8(69-71)

PURPOSE

This guide will assist you in determining the nitrite content of any water or wastewater. The nitrite test, like the nitrate test, helps determine the progressive destruction of organic nitrogen and ammonia as they react to form nitrate by the aerobic processes indicated below:

$$O_2 + N_2 + NH_3 \longrightarrow NO_2 + NO_3$$

PREREQUISITES

Before beginning this module you should have successfully completed Chem 101:46e, f(36) and 47j(37); and Env Sci 101:1i(49).

RESOURCES

IRIS: 4
"Methods for Chemical Analysis of water and Wastes" (IRIS number not yet assigned)

OBJECTIVES

OBJ 1: Describe and demonstrate the procedures for the preparation of containers for nitrite samples.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of the sample containers must meet the specifications in IRIS 4, including that no beads of water or stains will be evident.

OBJ 2: Select appropriate nitrite samples location in a wastewater treatment plant or on a watercourse.

COND: Given resources (IRIS 4), wastewater treatment plant operational guide or watercourse map, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Selection must include:

a. Location in plant
b. Location in process unit or stream
c. Depth
d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedures for collecting a nitrite sample.

COND: Given the nature of the sample (grab, composite), resources (IRIS 4), the location, and the necessary equipment and supplies.

PL: 90% of the sample taken must be taken in conformance with procedures in IRIS 4, including:

a. Depth
b. Sampling equipment needed
c. Time of day
d. Frequency (retention time considered)
e. Absence of floating matter
f. Collection of a representative sample
g. Labeling of container to show date, place, time, and name of person who collected sample

OBJ 4: Describe and demonstrate the procedure for transporting a nitrite sample to the laboratory.

COND: Given resources (IRIS 4) and the interval (up to 24 hours) of sampling to time of analysis.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures prescribed in IRIS 4, including:

a. Control of temperature
b. Exclusion of light
c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing a nitrite sample.

COND: Given resources (IRIS 4) and the interval (up to 24 hours) over which the sample must be kept in the laboratory.

PL: 95% of the samples stored must be suitable for analysis after the prescribed storage time.

OBJ 6: Describe and perform a nitrite analysis, including proper safety procedure.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of samples must fall within reasonable limits of deviation as defined in IRIS 4. Safety procedures must be followed 100% of the time.

Include:

a. List the following reagents and explain their roles in the analsis:
   1. hydrochloric acid
   2. sulfanilamide
   3. N-(naphthyl) ethylenediamine dihydrochloride
   4. sodium nitrite
   5. sodium acetate
   6. chloroform
b. List this equipment:
   1. spectronic 20
   2. balance
   3. pH meter
c. List these analytical supplies:
   1. bottles
   2. volumetric flasks
   3. spectrophotometer tubes
   4. pipets
d. Describe routine procedures for recording data.
e. Describe the calculations (in mg/1) for nitrate.
f. Prepare and standardize the necessary reagents.
g. Describe safety procedures.
h. Determine the nitrite content of each sample.

OBJ 7: Report and interpret the nitrite results using established technical report form.

COND: Given resources (IRIS 4).

PL: 90% of results must be correct and 80% of interpretation must conform to those in resources. The results will be interpreted by:

a. Obtaining standard curve by plotting the absorbance of the standards (minus blank) against mg NO_2 - N/1.
b. Reading the concentration of the unknown sample by using its value of absorbance (minus blank) and the curve.
c. Comparing the nitrite concentration with results of other groups performing the same analysis.
d. Explaining why any disagreement in results might occur.

OBJ 8: Recognize an abnormal condition in any of the analyses and suggest and take corrective action necessary to correct the abnormal condition.

COND: Given resources (IRIS 4).

PL: 80% of abnormal conditions must be spotted and corrected, including interference resulting from:

a. Strong oxidants
b. Strong reductants
c. High alkalinity

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
500 ml bottles (2)	x	x	x	x	x			
Spectrophotometer (540 nm)						x		
1 liter volumetric flask						x		
250 ml volumetric flask						x		
50 ml volumetric flask						x		
Spectrophotometer tubes						x		
10 ml pipet						x		
Analytical balance						x		
pH meter						x		
Graph paper							x	
Sample carrier				x				
Hydrochloric acid (conc. Hcl)						x		
Sulfanilamide						x		
N - (1-naphthyl) ethylenediamine dihydrochloride						x		
Sodium nitrite (anhydrous) ($NaNO_3$)						x		
Sodium acetate ($NaC_2H_2O_2$)						x		
Chloroform							x	

Total Phosphorus (Orthophosphates)

ENV SCI 102(17, 15):1-8(69-71)

PURPOSE

This guide will assist you in determining the total phosphorous content of any water or wastewater. This total phosphorous test:

1. measures the concentration of orthophosphates;
2. measures the concentration of polyphosphates;
3. measures the concentration of organic phosphorous.

PREREQUISITES

Before beginning this module you should have successfully completed Chem 101:46e, f(36) and 47j(37) and Env Sci 101:1h, i (49).

RESOURCES:

IRIS: 4, 480, 542
"Methods for Chemical Analysis of Water and Wastes" (IRIS number not yet assigned)

OBJECTIVES

OBJ 1: Describe and demonstrate the procedure for the preparation of containers for inorganic phosphorous samples.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of the sample containers must meet the specifications in IRIS 4, including that no beads of water or stains will be evident. Must take appropriate action to assure that all phosphorous absorbed on the glassware is removed.

OBJ 2: Select appropriate inorganic phosphorous sample location in a wastewater treatment plant or on a watercourse.

COND: Given resources (IRIS 4), wastewater treatment plant operational guide or watercourse map, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Include:

a. Location in plant
b. Location in process unit or stream
c. Depth
d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedures for collecting a phosphorous sample.

COND: Given the nature of the sample (grab, composite), resources (IRIS 4), the location, and the necessary equipment and supplies.

PL: 90% of the samples taken must be taken in conformance with procedures in IRIS 4, including:

a. Depth
b. Sampling equipment needed
c. Time of day
d. Frequency (retention time considered)

e. Absence of floating matter
f. Collection of a representative sample
g. Labeling of containers to show date, place, time, and name of person who collected sample
h. Preservation

OBJ 4: Describe and demonstrate the procedure for transporting a phosphorous sample to the laboratory.

COND: Given resources (IRIS 4) and the interval (up to 24 hours) from time of sampling to time of analysis.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures prescribed in IRIS 4, including:

a. Control of temperature
b. Exclusion of light
c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing a phosphorous sample.

COND: Given resources (IRIS 4) and an interval (up to 7 days) over which the sample must be kept in the laboratory.

PL: 95% of the samples stored must be suitable for analysis after the prescribed storage time.

OBJ 6: Describe and perform a phosphorous analysis, including proper safety procedure.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of samples must fall within reasonable limits of deviation. Safety procedures must be followed 100% of the time.

Include:

a. Prepare or obtain a list of chemicals, equipment, and analytical supplies needed to perform a persulfate digestion, followed by an ascorbic acid colorimetric determination.
b. List the reagents and explain their roles in the analysis.
c. Prepare and standardize the reagents.
d. Describe safety procedures.
e. Perform the phosphorous analysis.
f. Record data and calculate the phosphorous content.

OBJ 7: Report and interpret the inorganic phosphorous results, using established technical report form.

COND: Given resources (IRIS 4).

PL: 90% of results must be correct and 80% of interpretation must conform to those in resources. Results will be interpreted by:

a. Obtaining a standard curve by plotting the absorbance of the standards against (mg P/l).
b. Reading the concentration of the unknown sample by using its value of absorbance and the standard curve.
c. Comparing the phosphorous concentration with results of other groups performing the same analysis.
d. Explaining why any disagreement in results might occur.

OBJ 8: Recognize an abnormal condition in any of the analyses, and suggest and take corrective action necessary to correct the abnormal condition.

COND: Given resources (IRIS 4).

PL: 80% of abnormal conditions must be spotted and corrected, including interferences resulting from:

a. Arsenate
b. Fluoride
c. Thorium
d. Bismuth
e. Sulfide
f. Thiosulfate
g. Thiocyanate
h. Molybdate
i. Ferrous

Must also outline procedure to find:

a. Polyphosphate
b. Organic phosphorous
c. Orthophosphate without digestion

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES							
	1	2	3	4	5	6	7	8
Drying oven						x		
1000 ml volumetric flask	x					x		
100 ml volumetric flask	x					x		
10 ml graduated cylinder	x					x		
100 ml graduated cylinder	x					x		
Hot plate						x		
250 ml Erlenmeyer flask	x					x		
Spectrophotometer (Baush-Lomb) (20 or 70)		x				x		
500 ml volumetric flask	x					x		
250 ml dark glass bottles (2)	x					x		
500 ml dark plastic bottles (2)	x					x		
Refrigerator (4°C)					x			
20 ml volumetric pipet	x					x		
125 ml Erlenmeyer flask	x					x		
Graph paper						x	x	
Straightedge						x	x	
Sample carrier				x				

EQUIPMENT AND SUPPLIES (continued)

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Phenolphthalein indicator solution						x		
Sulfuric acid (conc. H_2SO_4)						x		
Ammonium persulfate $[(NH_4)_2S_2O_8]$						x		
Sodium hydroxide (NaOH)						x		
Ethyl alcohol (95%)						x		
Antimony potassium tartrate $[K(SbO)C_4H_4O_6 \cdot \frac{1}{2}H_2O]$						x		
Ammonium molybdate $[(NH_4)_6Mo_7O_{24}4H_2O]$						x		
Ascorbic acid						x		
Potassium dihydrogen phosphate (KH_2PO_4)						x		
Hydrochloric acid (HCl)	x							

Total Organic Carbon

ENV SCI 102(16):1-8(69-71)

PURPOSE

This guide will assist you in learning how to perform the analysis for total organic carbon. This test is used to analyze for all forms of organic carbon without discrimination, so any pretreatment may affect the results and should be clearly stated. The presence of carbonate and bicarbonate will appear as total organic carbon unless removed or subtracted after analysis.

PREREQUISITES

Before beginning this module you should have successfully completed Chem 102(57) and Env Sci 101:1,2(49).

RESOURCES

IRIS: 4, 771
"Methods for Chemical Analysis of Water and Wastes" (IRIS number not yet assigned)

OBJECTIVES

OBJ 1: Describe and demonstrate the procedure for the preparation of containers for the total organic carbon analysis.

COND: Given one of the resources and an equipped laboratory.

PL: 90% of the sample containers must meet the specifications in one of the above resources, with great care to prevent all organic contamination, such as detergents.

OBJ 2: Describe and demonstrate the procedure for collecting a sample for the total organic carbon analysis.

COND: Given one of the resources, a location, and the nature of the sample.

PL: 90% of the samples taken must be taken in conformance with procedures in one of the above resources, including:

a. Depth
b. Sampling equipment needed
c. Time of day
d. Frequence
e. Preservation

OBJ 3: Describe and demonstrate the procedure for transporting a sample to the laboratory for total organic carbon analysis.

COND: Given one of the resources and a 24-hour time limit for transportation.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures described in one of the above resources, especially with no organic contamination.

OBJ 4: Describe and demonstrate the procedure for storing samples in the laboratory for total organic carbon analysis.

COND: Given one of the resources and the storage time required, up to 24 hours.

PL: 95% of the samples stored must be suitable for analysis after the prescribed storage time.

OBJ 5: Select appropriate sample location in plant or on watercourse for total organic carbon analysis.

COND: Given one of the following resources:

a. Plant operational guide for plant in question.
b. One of the listed resources above.

Given the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting a regulatory requirement.
c. Meeting a process requirement.

PL: Include:

a. Location in plant
b. Location in process unit or on stream
c. Depth

OBJ 6: Describe and perform the analysis for the total organic carbon analysis, including proper sampling procedure.

COND: Given one of the listed resources and an equipped laboratory.

PL: 90% of samples must fall within acceptable range as defined in one of the resources. Safety procedures must be followed 100% of the time.

OBJ 7: Describe and perform the procedure for the total organic carbon analysis, including reporting and interpreting the results.

COND: Given one of the resources, standard curves, and the data.

PL: 90% of results must be correct and 80% of interpretation must conform to those in resources.

OBJ 8: Recognize an abnormal condition in the total organic carbon analysis in any performance in objectives 1-7, and suggest and take the action necessary to correct the abnormal condition.

COND: Given one of the following resources:

a. Laboratory control guide for plant in question.
b. One of the resources above.

Given charts, nomographs, standard curves, calculator, laboratory logbooks.

PL: 80% of abnormal conditions must be spotted and corrected to meet performance level in objective 1-7.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
30 ml beakers						x		
Blender						x		
Hypodermic syringe (500 ml)						x		
Magnetic stirrer						x		
Packing for oxidation tube of total organic carbon analyzer						x		

EQUIPMENT AND SUPPLIES (continued)

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Redistilled water						x		
Sample bottles	x	x	x	x		x		
Total organic carbon analyzer						x		
1 liter volumetric flasks						x		
Standard carbon solution containing sodium oxalate						x		
Hydrochloric acid						x		
Nitrogen gas - CO_2 free						x		
Oxygen gas - CO_2 free						x		

Alkalinity, Acidity, and pH

ENV SCI 102(19,18,9):1-8(69-71)

PURPOSE

This guide will assist you in determining the acidity and alkalinity of a water sample. The alkalinity of a water sample is a measure of its capacity to neutralize acids. The three major ions which contribute to the alkalinity of water are: 1. hydroxide, 2. carbonate, and 3. bicarbonate. These ions, usually provided by salts of weak acids or strong bases, act to prevent a drop in pH even when acid is being added. The equations below show how each of these ions neutralizes the H^+, which is the acid character of solutions.

1. $OH^- + H^+ \longrightarrow HOH$
2. $CO_3^= + H^+ \longrightarrow HCO_3^-$
3. $HCO_3^- + H^+ \longrightarrow H_2CO_3$

In this guide you will measure this buffering action (alkalinity) in a water sample.

The acidity of a water sample is a measure of its capacity to neutralize bases. The two main types of acidity are: 1. carbon dioxide acidity, and 2. mineral acidity. The equations below show how CO_2, S, FeS_2, and $FeCl_3$ act to produce acidity.

1. $CO_2 + H_2O \rightleftharpoons H_2CO_3$

   $H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$

   $HCO_3^- \rightleftharpoons H^+ + CO_3^=$

2. $2S + 3O_2 + 2H_2O \rightleftharpoons 2H_2SO_4$

   $H_2SO_4 \rightleftharpoons 2H^+ + SO_4^=$

3. $2FeS_2 + 7O_2 + 2H_2O \rightleftharpoons FeSO_4 + H_2SO_4$

   $H_2SO_4 \rightleftharpoons 2H^+ + SO_4^=$

4. $FeCl_3 + 3H_2O \rightleftharpoons Fe(OH)_3 + 3H^+ + 3Cl$

In this guide you will measure the acidity of a water sample.

As noted on the preceding page, there are three main types of alkalinity and two types of acidity. The pH of the water sample determines which type will be present. The chemistry of the reactions governed by this pH is beyond the scope of this guide, but is covered in Chem 102(57).

PREREQUISITES

Before beginning this module you should have successfully completed Chem 101:46e, f(36) and 47j(37); and Env Sci 101:1h (49).

RESOURCES

IRIS: 4, 413, 466, 1027
"Methods for Chemical Analysis of Water and Wastes" (IRIS number not yet assigned)

OBJECTIVES

OBJ 1: Describe and demonstrate the procedures for the preparation of containers for alkalinity and acidity samples.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of the sample containers must meet the specifications in IRIS 4.

OBJ 2: Select appropriate alkalinity and acidity sample location in a wastewater treatment plant or on a watercourse.

COND: Given resources (IRIS 4), wastewater treatment plant operational guide or watercourse map, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Include:

a. Location in plant
b. Location in process unit or stream
c. Depth
d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedures for collecting an alkalinity and acidity sample.

COND: Given the nature of the sample (grab, composite), resources (IRIS 4), the location, and the necessary equipment and supplies.

PL: 90% of the samples taken must be taken in conformance with procedures in IRIS 4, including:

a. Depth
b. Sampling equipment needed
c. Time of day
d. Frequency
e. Absence of floating matter
f. Collection of a representative sample
g. Labeling of container to show date, place, time, and name of person who collected sample
h. Preservation

OBJ 4: Describe and demonstrate the procedure for transporting an alkalinity and acidity sample to the laboratory.

COND: Given resources (IRIS 4) and the interval (up to 24 hours) from time of sampling to time of analysis.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis

in conformance with procedures described in IRIS 4, including:

a. Control of temperature
b. Exclusion of light
c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing an alkalinity and acidity sample.

COND: Given resources (IRIS 4) and the time interval over which the sample must be kept in the laboratory.

PL: 95% of the samples stored must be suitable for analysis after the prescribed time.

OBJ 6: Describe and perform an alkalinity and acidity analysis, including proper safety procedure.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of samples must fall within reasonable limits of deviation as defined in IRIS 4. Safety procedures must be followed 100% of time.

Include:

a. List the following reagents and explain their roles in the analysis:
    1. sodium hydroxide
    2. potassium biphthalate
    3. hydrochloric acid
    4. sulfuric acid
    5. sodium thiosulfate
    6. sodium carbonate
b. List this equipment:
    1. hot plate
    2. balance
    3. pH meter
c. List these analytical supplies:
    1. buret
    2. beaker
    3. flasks
    4. volumetric flasks
    5. dropper
d. Describe routine procedures for recording data.
e. Describe the calculations in (mg/l $CaCO_3$) for acidity and alkalinity.
f. Prepare and standardize the necessary reagents.
g. Describe safety procedures.
h. Determine the acidity and alkalinity for each sample.

OBJ 7: Report and interpret the alkalinity and acidity results using established technical report form.

COND: Given resources (IRIS 4).

PL: 90% of results must be correct and 80% of interpretation must conform to those in resources. The results will be interpreted by:

a. Comparing the acidity and alkalinity with results of other groups performing the same analysis.
b. Explaining why any disagreement in results might occur.

OBJ 8: Recognize an abnormal condition in any of the analyses and suggest and take corrective action necessary to correct the abnormal condition.

COND: Given resources (IRIS 4).

PL: 80% of abnormal conditions must be spotted and corrected, including interferences resulting from:

a. Iron sulfate
b. Aluminum sulfate
c. Residual chlorine
d. Calcium carbonate
e. Magnesium hydroxide
f. Salts of weak inorganic and organic acids

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
50 ml buret						x		
Hot plate						x		
250 ml beaker						x		
250 ml Erlenmeyer flask						x		
Analytical balance that weighs to 0.001 grams						x		
1 liter volumetric flask						x		
100 ml graduated cylinder						x		
Sample carrier				x				
Thermometer						x		
pH meter						x		
Concentrated sulfuric acid (H_2SO_4)						x		
Anhydrous (primary standard grade) sodium hydroxide (Na_2CO_3)						x		
Sodium hydroxide (NaOH)						x		
Hydrogen peroxide (H_2O_2) (30% solution)						x		

Hardness

ENV SCI 102(20):1-8(69-71)

PURPOSE

This guide will assist you in determining the hardness of a water sample. Hard waters are those water supplies which produce scale ($CaCO_3$) when heated, and also require large amounts of soaps and detergents to produce clean clothes.

The scale found in hot water heaters, pipes, and boilers (even in tea kettles) is due to the high temperature precipitation of calcium carbonate from calcium bicarbonate according to the equation:

$$Ca(HCO_3)_2 \longrightarrow CaCO_3\downarrow + H_2) + CO_2\uparrow$$

The cost of chemicals to prevent such precipitation is usually high, and thus the sanitary engineer seeks to avoid hard water supplies.

Calcium and magnesium ions in water are causative agents of the soap curds that are often found in clothes washers in hard water areas. The formation of these curds, produced as Ca^{+2} and Mg^{+2} ions combined with the soap molecule, is represented as follows:

$$2C_{17}H_{35}COONa + Ca(HCO_3)_2 \longrightarrow$$

$$(C_{17}H_{35}COO)_2Ca\downarrow + 2NaHCO_3$$

The equation indicates that the soap preferentially attracts the Ca^{+2} ion, rather than the dirt particles it was meant to attract.

Hard water, therefore, needs an extra amount of soap to satisfy the ion requirement before the dirt requirement can be met.

PREREQUISITES

Before beginning this module you should have successfully completed Chem 101: 46e,f(36) and 47j(37).

RESOURCES

IRIS: 4, 1363, 2575
"Methods for Chemical Analysis of water and Wastes" (IRIS number not yet assigned)

OBJECTIVES

OBJ 1: Describe and demonstrate the procedures for the preparation of containers for hardness samples.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of the sample containers must meet the specifications in IRIS 4, including that no beads of water or stains will be evident.

OBJ 2: Select appropriate hardness sample location in a wastewater treatment plant or on a watercourse.

COND: Given resources (IRIS 4), drinking water treatment plant operational guide or watercourse map, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Include:
- a. Location in plant
- b. Location in process unit or stream
- c. Depth
- d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedure for collecting a hardness sample.

COND: Given the nature of the sample (grab, composite), resources (IRIS 4), the location, and the necessary equipment and supplies.

PL: 90% of the samples taken must be taken in conformance with procedures in IRIS 4, including:
- a. Depth
- b. Sampling equipment needed
- c. Time of day
- d. Frequency (retention time considered)
- e. Absence of floating matter
- f. Collection of a representative sample
- g. Labeling of container to show date, place, time, and name of person who collected sample

OBJ 4: Describe and demonstrate the procedure for transporting a hardness sample to the laboratory.

COND: Given resources (IRIS 4) and the interval (up to 7 days) from time of sampling to time of analysis.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures prescribed in IRIS 4, including:
- a. Control of temperature
- b. Exclusion of light
- c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing a hardness sample.

COND: Given resources (IRIS 4) and the time interval (up to 7 days) over which the sample must be kept in the laboratory.

PL: 95% of the samples stored must be suitable for analysis after the prescribed storage time.

OBJ 6: Describe and perform a hardness analysis, including proper safety procedure.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of samples must fall within reasonable limits of deviation. Safety procedures must be followed 100% of the time.

Include:
- a. Prepare or obtain a list of reagents, equipment, and analytical supplies needed to perform the hardness tests.
- b. Describe the end points in the titrations.
- c. Describe the routine procedures for recording data.
- d. Describe the calculations (in mg/l $CaCO_3$) for total and CA^{+2} hardness.
- e. Prepare and standardize the necessary reagents.
- f. Describe safety procedures.
- g. Determine the hardness of each sample.

OBJ 7: Report and interpret the hardness results using established technical report form.

COND: Given resources (IRIS 4).

PL: 90% of results must be correct and 80% of interpretations must conform to

those in resources. The results will be interpreted by:

a. Calculating the Ca^{++}, Mg^{++}, and Total Hardness.
b. Comparing the hardness values with results of other groups performing the same analysis.
c. Explaining why any disagreement in results might occur.

OBJ 8: Recognize an abnormal condition in any of the analyses and suggest and take corrective action necessary to correct the abnormal condition.

COND: Given laboratory control guide for plant in question, typical hardness curves and data, laboratory logbooks, and a calculator.

PL: 80% of abnormal conditions must be spotted and corrected, including interferences resulting from:

a. Strontium
b. Silica
c. Aluminum
d. Iron
e. Manganese
f. Phosphate
g. Suspended matter

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
50 ml buret						x		
250 ml Erlenmeyer flask						x		
50 ml graduated cylinder						x		
10 ml graduated cylinder						x		
Eyedropper						x		
pH meter						x		
Sample carrier				x				
500 ml bottles (2)				x				
100 ml volumetric flask						x		
1 liter volumetric flask						x		
Magnesium salt of EDTA						x		
Eriochrome Black T						x		
Sodium chloride (NaCl)						x		

EQUIPMENT AND SUPPLIES (continued)

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Disodium salt of EDTA						x		
Hydrochloric acid (HCl)						x		
Ammonium chloride (NH_4Cl)						x		
Ammonium hydroxide (NH_4OH)						x		
Calcium carbonate ($CaCO_3$ anhydrous) (primary standard)						x		
Sodium hydroxide (NaOH)						x		
Murexide						x		

Volatile Acids (Total Organic Acids)

ENV SCI 102(21,22):1-8(69-71)

PURPOSE

This guide will assist you in determining the volatile acid content of a sample by use of the total organic acid method. The determination of volatile acids in sludge provides valuable information on the efficiency of sludge digestion. In normal anaerobic digestor operation, the organic materials in the sludge are first converted to low molecular weight compounds (chiefly volatile acids, of which 70% is usually acetic acid), and then these compounds are converted to methane and carbon dioxide by methane-forming bacteria. When the digestor operates efficiently, the bacteria form methane and the volatile acid content of digesting sludge remains in the range of 50-250 mg/l (expressed as acetic acid). At pH values below 6.5, the methane bacteria are seriously inhibited, and the volatile acid concentration increases to levels of 250 mg/l or higher. These high levels indicate that the organic solids are no longer being efficiently converted to methane and carbon dioxide, and that corrective action must be taken to restore the digestor to proper operation.

PREREQUISITES

Before beginning this module, you should have successfully completed Chem 101: 46e,f(36) and 47j(37).

RESOURCES

IRIS: 4, 142

OBJECTIVES

OBJ 1: Describe and demonstrate the procedures for the preparation of containers for volatile acids samples.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of the sample containers must meet the specifications in IRIS 4, including that no beads of water or stains will be evident.

OBJ 2: Select appropriate volatile acids sample location in a wastewater plant.

COND: Given resources (IRIS 4), wastewater treatment plant operational guide, and the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting regulatory requirements.
c. Meeting a process requirement.

PL: Include:

a. Location in plant
b. Location in process unit
c. Depth
d. Obtaining a representative sample

OBJ 3: Describe and demonstrate the procedures for collecting a volatile acid sample.

COND: Given the nature of the sample (grab, composite), resources (IRIS 4), the location, and plant operational manual.

PL: 90% of the samples taken must be taken in conformance with procedures in IRIS 4, including:

a. Depth
b. Sampling equipment needed
c. Time of day
d. Frequency
e. Collection of a representative sample
f. Labeling of container to show date, place, time, and name of person who collected sample

OBJ 4: Describe and demonstrate the procedure for transporting a volatile acid sample to the laboratory.

COND: Given resources (IRIS 4) and the interval (usually within 6 hours) from time of sampling to time of analysis.

PL: 95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures described in IRIS 4, including:

a. Control of temperature
b. Exclusion of light
c. Addition of preservative chemicals

OBJ 5: Describe and demonstrate the procedure for storing a volatile acid sample.

COND: Given resources (IRIS 4) and the time interval (usually within 6 hours) over which the sample is to be stored in the laboratory.

PL: 95% of the samples stored must be suitable for analysis after the prescribed storage time.

OBJ 6: Describe and perform a volatile acid analysis, including proper safety procedure.

COND: Given resources (IRIS 4) and an equipped laboratory.

PL: 90% of samples must fall within reasonable limits of deviation. Safety procedures must be followed 100% of the time.

Include:

a. List the following reagents and explain their roles in the analysis:
   1. silicic acid
   2. chloroform
   3. n-butanol
   4. sulfuric acid
   5. thymol blue
   6. methanol
   7. phenolphthalein
   8. sodium hydroxide
b. List this equipment:
   1. gravity filter
   2. desiccator
   3. gas (CO_2) supply
c. List these analytical supplies:
   1. beakers
   2. separatory funnel
   3. filter paper
   4. funnel
   5. pipet
   6. gooch crucible
   7. filtering flask
   8 buret
d. Describe routine procedures for recording data.
e. Describe the calculations (in mg/l) for volatile acids.
f. Prepare and standardize the necessary reagents.
g. Describe safety procedures.
h. Determine the volatile acid content of each sample.

OBJ 7: Report and interpret the volatile acids results using established technical report form.

COND: Given resources (IRIS 4).

PL: 90% of results must be correct and 80% of interpretations must conform to those in resources. The results will be interpreted by:

a. Comparing results with those of other groups performing the same analysis.
b. Showing any disagreement.
c. Explaining why any disagreement in results might occur.

OBJ 8: Recognize an abnormal condition in any of the analyses and suggest and take corrective action necessary to correct the abnormal condition.

COND: Given resources (IRIS 4).

PL: 80% of abnormal conditions must be spotted and corrected, including interferences resulting from:
a. High volatile acid concentration (5000 mg/l).
b. Presence of other organic acids.
c. Appearance of a white precipitate.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
100 ml glass or plastic bottle		x						
Centrifuge/vacuum filtering assembly						x		
Gooch crucible						x		
GFC filter paper						x		
1000 ml beaker						x		
Oven 103°C						x		
Separatory funnel (500 ml)						x		
Gravity filter						x		
Filter paper						x		
Eyedropper						x		
5 ml pipet						x		
He gas tank						x		
50 ml buret						x		
Sample carrier				x				
Silicic acid						x		

EQUIPMENT AND SUPPLIES (continued)

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
Chloroform						x		
n - butanol						x		
Sulfuric acid (H_2SO_4)						x		
Thymol blue indicator						x		
Methanol (absolute)						x		
Phenophthalein						x		
Sodium hydroxide (NaOH)						x		

Appendix I
IRIS RESOURCES

CODE DEFINITIONS

AC	audio tape cassette	OT	overhead transparency
FS	35mm filmstrip	PM	printed matter
MP	motion picture	SL	35mm slide

NUMBER	TITLE	SOURCE/AUTHOR	TYPE OF MATERIAL
4	Standard Methods for the Examination of Water and Wastewater	WPCF	PM
41	AWWA Standard for Sodium Chloride	AWWA	PM
60	AWWA Standard for Sodium Fluoride	AWWA	PM
108	Supervisors Workshop	NFI	PM
125	Operation of Wastewater Treatment Plants	WPCF	PM
142	Analysis of Wastewater Samples	NY Dept. of Health	PM SL
281	Supervisory Problems Workshop and Reference Manual	DuPont	PM
282	Temperature Measurement Basic Physics and Terms	DuPont	PM
283	Temperature Measurement Scales and Conversion	DuPont	PM
284	Temperature Measurement Thermometers	DuPont	PM
285	Titration and ITS Glassware	DuPont	PM
289	Water Treatment - Water Chemistry	DuPont	PM
291	Water Treatment - Water Testing	DuPont	PM
381	Office Management	Lansford	OT
399	Technical Report Writing (out of print)	Lansford	OT
404	Fundamentals of Analytical Chemistry	Lansford	OT
413	Determination of Alkalinity	EPA	AC PM SL
466	Alkalinity	EPA	AC PM SL

NUMBER	TITLE	SOURCE/AUTHOR	TYPE OF MATERIAL
480	Our Environment Battles Water Pollution	Renn, C. E.	PM
481	Study of Water Quality	Renn, C. E.	PM
488	Investigating Water Problems - A Water Analysis Manual	Renn, C. E.	PM
538	Atomic Absorption	EPA WPO	AC PM SL
539	Chemical Oxygen Demand	EPA	AC PM SL
540	Dissolved Oxygen Determination	EPA	AC PM SL
542	Determination of Phosphorus	EPA	AC PM SL
547	Operational Control Tests for Activated Sludge Process - Part 3	EPA	AC PM SL
556	Residual Chlorine and Chlorine Demand	EPA	AC PM SL
557	Determination of Chemical Oxygen Demand	EPA	AC PM SL
618	Water Measurement Manual	Interior Dept.	PM
771	Determination of Total Organic Carbon	EPA	AC PM SL
830	Recommended Standards for Sewage Works - Ten State Standards	NY HES	PM
850	Use of Spectromic 20 Spectrophotometer	EPA	AC PM SL
879	Practical Guide to Water Quality Studies of Streams	Kittrell, F. W.	PM
902	Determination of Suspended Solids	EPA	AC PM SL
1017	Control of Sulphides in Sewerage Systems	Thistlelkwayte, D.	PM
1027	Applied Chemistry of Wastewater Treatment - Unit 8 - Applications - pH and Alkalinity	Mancy, K. H.	PM
1036	Water Quality Instrumentation, Vol. 2	Scales, J. W.	PM
1060	Sartorius Balance 2400	Slabaugh, W. H.	MP
1061	Colorimetry - Part I	Slabaugh, W. H.	MP
1062	Colorimetry - Part II	Slabaugh, W. H.	MP
1063	pH Meter	Slabaugh, W. H.	MP
1143	Titration	Kalmia	MP

NUMBER	TITLE	SOURCE/AUTHOR	TYPE OF MATERIAL
1226	Writing Letters That Get Results	Roundtable	PP
1331	Biological Field Investigative Data for Water Pollution Surveys (out of print)	Ingram	PM
1332	Biological Associated Problems in Freshwater Environments - Their Identification, Investigation and Control	Mackenthun	PM
1352	How to Make Serial Dilutions	AIBS	AC FS PM SL
1363	How to Measure Water Hardness	AIBS	AC FS PM SL
1370	Laboratory Procedures - Analysis for Wastewater Treatment Plant Operators	Wietti, D.	PM
1413	How to Measure Dissolved Oxygen Content of Water	AIBS	AC FS PM SL
1414	How to Grow and Count Microorgansims on Membrane Filters	AIBS	AC FS PM SL
1426	Treatment and Disposal of Wastewater Sludges	Wesilind, P. A.	PM
1429	Atomic Spectrometric Analysis of Heavy Metal Pollutants in Water	Burrell, D. C.	PM
1505	Introduction to Environmental Technology - Vol. I of Wastewater Technology	Clemson University	PM
1506	Plant Operations for Wastewater Facilities - Vol. II of Wastewater Technology	Clemson University	PM
1583	Office Records Management	Lansford	OT
1755	Water Quality Parameters	ASTM	PM
1762	pH Meter - Laboratory Operation	EPA	AC PM SL
1795	Modern Chemical Technology - Vol. 5	ACS	PM
1823	Water Use Classifications and Standards of Water Quality	NEIWPCC	PM
1886	Temperature Measurement - Standards and Calibration	DuPont	PM
1915	Wastewater Treatment Technology	Patterson, J. W.	PM

NUMBER	TITLE	SOURCE/AUTHOR	TYPE OF MATERIAL
2075	Processing Water Treatment Plant Sludge	AWWA	PM
2105	Common Laboratory Apparatus	Comm Skill	AC FS PM SL
2106	Pipetting Techniques	Comm Skill	AC FS PM SL
2110	pH Measurements	Comm Skill	AC FS PM SL
2116	Temperature	Mitchel, J. P.	AC FS PM SL
2122	pH, pOH and Buffers	Mitchell, J. P.	AC FS PM SL
2127	Dilution and Titration Problems	Mitchell, J. P.	AC FS PM SL
2134	Basic Relationships and Instrumentation Basic Gas Chromatography	McNair, H. M.	AC FS PM SL
2135	Column ITS Make Up and Use	McNair, H. M.	AC FS PM SL
2136	Detectors - Design and Use	McNair, H. M.	AC FS PM SL
2137	Sample Preparation Derivatives and Sampling Technique	McNair, H. M.	AC FS PM SL
2138	Column Temperature Programming	McNair, H. M.	AC FS PM SL
2139	Qualitative and Quantitative Analysis	McNair, H. M.	AC FS PM SL
2141	Derivatives for Gas Chromatography	McNair, H. M.	AC FS PM SL
2143	Principles of Atomic Absorption	Robinson, J. W.	AC FS PM SL
2144	Instrumental Requirements - Basic Atomic Absorption Spectroscopy Series	Robinson, J. W.	AC FS PM SL
2145	Optimizing Instrument Conditions - Basic Atomic Absorption Spectroscopy Series	Robinson, J. W.	AC FS PM SL
2146	Sample Preparation and Special Sampling Techniques	Robinson, J. W.	AC FS PM SL
2302	Basic Principles of the Analytical Balance	USPHS	MP
2510	Management and Supervision Procedures for Wastewater Facilities - Vol. IV of Wastewater Technology	Clemson University	PM
2534	Safety Pipetting	USNMAC	MP
2558	Self-Monitoring Procedures - Basic Parameters for Municipal Effluents - Staff Guide	EPA	PM

NUMBER	TITLE	SOURCE/AUTHOR	TYPE OF MATERIAL
2559	Self-Monitoring Procedures - Basic Parameters for Municipal Effluents - Student Reference Manual	EPA	PM
2575	Hardness of Drinking Water and Public Health	Amavis, R.	PM
2758	Stream - Gauging Procedures	Corbett, D. M.	PM
2759	Field Manual for Research in Agricultural Hydrology	Holtan, H. M.	PM
2911	Basic Laboratory Techniques for NPDES	Bonnette, A. K., Lamb, D., Allen, J. F.	PM